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SCHOOL SCIENCE AND MATHEMATICS

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SCHOOL SCIENCE AND MATHEMATICS

VOL. XXVIII NO. 2 FEBRUARY, 1928 WHOLE NO. 238

THE ROMANCE OF LOGARITHMS.

BY FRANCES E. ANDREWS,

Lane Technical School, Chicago.

The mathematics classroom deals little enough in Romance. The simplest possible exposition of the most unvarying facts—this is our daily job. But the teacher needs occasionally to lift his head above the swarming details and problems of that daily job to revive his sense of the great sweep of mathematical history, freshen his view point with the remembrance of the achievements in the face of tremendous difficulties attained by figure after figure in that history, and to rekindle the fires of his enthusiasm with the thought of the great strides in science and civilization which have been made possible by and have followed each of the great mathematical inventions. The story of the invention of logarithms by John Napier, Baron of Merchistoun, is but one of the stirring and curious tales of personal achievement with which that history is enlivened.

At the time of their discovery the logarithms were hailed as marvelous indeed. When Henry Briggs first met John Napier, he exclaimed: "My lord, I have undertaken this long journey purposely to see your person, and to know by what engine of wit or ingenuity you came first to think of this most excellent help in astronomy, viz., the logs." Today writer after writer acclaims the invention the most remarkable event in the history of mathematics. And when we consider the state of civilization in Scotland and the state of science everywhere, we too can begin to see the wonder of the publication in 1614 of such a book as Napier's *Descriptio.*

What, then, were these conditions under which this man Na-

pier lived and pursued his studies? Scotland under the unfortunate Mary and her guileful son was seething with the religious controversy which was to cleave the nation. Down in London under the patronage of Elizabeth, the golden age of English literature was flourishing, but even there science had not progressed far, while up in Edinburg the peaceful arts and sciences were all held back by the continual border warfare. Neither England nor Scotland had ever yet produced a scientist of note. Mark Napier in his *Memoirs of John Napier* describes the period as "the most savage age of a barbarous land."

In the way of science the world over the outlook was little better. The age was credulous and superstitious. Even Kepler, one of the most noted scientists of the time, believed in astrology, and filled his works with references to magic. Stifel was converted to Lutheranism only when he observed that Leo X was the beast mentioned in Revelations. He knew this because, discarding the "m" which obviously stands for mysterium, the numbers which represent the letters in "Leo decimus" add up to exactly ten less than 666. Moreover, even aside from this almost childish superstition of the most learned scholars, one would not have thought that mathematics had progressed far enough to make possible the conception and completion of the logarithmic tables. Exponents, upon which we base our explanation of logarithms were not invented till long after Napier's death; algebra was in such a primitive state that our conception of a function was unknown; and arithmetic was hopelessly hampered by the fact that decimal fractions had but just been discovered, and the notation for them was very awkward. Though the decimal system for integers was introduced in the tenth century, the extension of the system to fractions came just at Napier's time. Some of his contemporaries used 3 (1) 7 (2) 5 (3) 9 (4) where we should write .3759. The decimal point appears on the first page of the English translation of Napier's tables. If he was not the first inventor, he was probably an independent discoverer of the value of the point.

In addition, there had been little previous work pointing the road to logarithms, no partial working out of the theory by other men. Napier produced a work entirely unique in mathematical literature. Part of his theory was indeed based on the relation of the arithmetic to the geometric progression, a relation which was well known. Archimedes, in *Arenarius*, compares the progressions

1	2	3	4	5	6	7	8	. . .	15
2	4	8	16	32	64	128	256	. . .	32768

and notes that the product of 4 and 16 holds the same position in the latter progression that the sum of 2 and 4 does in the first, and that the product of 128 and 256 corresponds to the sum of 7 and 8. A Portuguese, Alvarus Thomas, graphically represented the two progressions. Michael Stifel (1486-1567), the Augustin monk who was converted to Lutheranism, has been, by some authors, too hastily given credit for inventing logarithms because of a passage in one of his works in which he compared arithmetic and geometric progressions. But none of these men had any thought of using the relationship they observed as the basis of a system for shortening calculations. Nor was that relationship by any means the whole of Napier's theory. Wright published a table for determining errors in navigation and Stevin one for calculating interest, both of which were really logarithmic tables, though their authors did not realize the fact, nor see their general applicability to fields outside their own special interests.

There was one man who was working directly along the lines of Napier's investigations, one Jobst Burgi (1552-1632), a Swiss watch maker who had worked with Kepler at Prague. According to his brother-in-law, and to Kepler, he was working on his tables before the publication of Napier's work, but his results were not published until 1620, several years after Napier's had appeared. At one time considerable interest was aroused by the discovery of what purported to be age old tables of Chinese logarithms, but investigation proved that every error made in one of the early editions of Napier's logarithms was reproduced in these supposed relics of antiquity.

The only sign of the times which at all pointed to logarithms was the direction which scientific research was taking. Men were devoting their lives to laborious calculations. Kepler was working out his laws of planetary motion, based on Tycho Brahe's painstaking observations; Galileo was perfecting his telescope, with which new observations and more intricate astronomical calculations were to come into vogue. Various German mathematicians were calculating trigonometrical tables: Georg Hoachim Rheticus published a table of sines only three years before the discovery of logarithms was made known to the world. His tables, the work on which would have been reduced by years with the aid of logarithms, have never been

superseded. L. Van Ceulen spent a life time calculating the value of pi to 35 decimal places. One is almost led to believe that these scientists of the latter half of the sixteenth century delighted in surpassing one another in the quantity of arithmetical calculation they could work out, but Napier, at least, recognized the fearful amount of time thus consumed. He says in the preface to the volume which contained his logarithmic tables, "There is nothing (right well beloved students in the mathematics) that is so troublesom to mathematicall practise, nor that doth more molest and hinder calculators, than the multiplications, divisions, square and cubical extractions of great numbers, which besides the tedious expense of time are for the most part subject to many slippery errors."

With all this in mind we can not help but wonder what kind of a man was this John Napier who stands at the head of the procession of Great Britain's scientists, who in the middle of a dark age flamed forth into the glory of achievement, lighting a torch which has been passed unextinguished down a long line of men of scientific genius the English-speaking people may well be proud to call their own.

He was, first of all, that typically Anglo-Saxon product, the eldest son of an ancient and honorable house, the eighth Napier of Merchiston. Three Napiers had been killed in battle and several had been knighted. The name had long been known in the public affairs of the nation. His father was director of the Scottish mint for a time and long a justice in Edinburg. Merchiston Castle still stands, a tall angular building set on a hill looking down the river to Edinburg, but little changed since the decade 1550 to 1560 when it sheltered the childhood of John Napier. From there the boy was sent at the age of thirteen to the University of St. Andrews where he was introduced to the theological controversies of his time. Before he was ready to receive a degree he was sent abroad to study. On his return a castle was built for him on the banks of the Endrik and he lived there until the death of his father in 1608 when he moved to Merchiston. He died at Merchiston in 1617, leaving considerable personal property in addition to the estates which he had inherited.

Aside from these bare outlines of his personal life and the evidence of his published works, our knowledge of him is vague. Most of his own papers were destroyed by a fire after his death. His character, however, we may attempt to

reconstruct from such fragmentary material as is left to us.

Most writers seem to agree that his chief interest in life was not in mathematics but in religious criticism and controversy. That his religion was real or at least pervasive of all phases of his life, one may conclude from the way in which even his mathematical works are interwoven with religious sentiment. He ended the *Descriptio* with the words: "Let those who reap the harvest of this small work pay a tribute of glory and thankfullness to God, sovereign author and dispenser of all good." He hated the Pope like a good Protestant; he felt keenly the need of setting the English people right on this subject and so in 1593 he published his "*Plaine Discovery*," an interpretation of St. John's Revelation which showed beyond a doubt that the seven hilled city of Rome was the Mother of Spiritual Whoredom therein described. In his own words he was "constrained of compassion, leauing the Latine, to haste out in English this present work, almost unripe, that hereby the simple of the Iland might be instructed." This work may well be a "witness to his bigotry" as one author says, but it was nevertheless a pioneer work in religious interpretation. Herein he shows the qualities which made it possible for him of all men to evolve his tables of logarithms, for he made a thorough and conscientious study and interpretation of the Book of Revelations to prove his point, free from the animosity and virulent prejudice of his contemporaries. The book had a wide circulation, being translated into Dutch, French, and German soon after it appeared in English.

We are told that he passed among the common folk of the country side for a trafficker with Satan. We find traces of what seem to us most childish beliefs on his part. One of the few of his manuscripts that was preserved was a paper on the principles of alchemy, addressed to his son, who was instructed to keep them very secret. He is reported to have had a jet black cock which was able to tell him the inmost thoughts of his domestics. One of his acquaintances was Robert Logan of Restalrig, a desperado who had obtained possession of a neighboring castle. With him Napier contracted "to serche and sik out, and be al craft and ingyne that he dov, to tempt, trye, and find out" some treasure supposed to be hidden in Robert's castle, in consideration of a part of the treasure, supposing it to be found. With all this, we are assured that he was much less a thrall to the ignorance and superstition of his age than most of his contemporaries.

His mind seems to have run to practical affairs. The invention of logarithms is proof enough of that, but additional testimony is contained in his other activities. He was much interested in agriculture, inventing a salted manure. After the Spanish Armada incident, he turned his attention to implements of war, and invented several ingenious but un-workable devices.

The humility revealed in the following passage is I think more than the formal modesty of an author: ". . . I graunte indeed and am sure, that in the style of words and utterance of language, we shall greatlie differ, for therein I do judge my selfe inferiour to all men: so that scarcely in these high matters could I with long deliberation finde wordes to express my mind." However, if we could draw conclusions from one incident, we should certainly find evidence of imperiousness and self centered interest in the fact that whenever he wished to be undisturbed, he requested the owner of the lint mill across the river from his castle to shut down the mill, so that its clatter might not interfere with his chain of thought. His mathematical works were all written in Latin; he seems to have had the usual scholar's contempt for English. He speaks of it as "a base language" (preface to *The Plaine Discovery*), the "vulgar English tongue" (preface to Wright's edition of the *Descriptio*). Lord Moulton's impression of Napier's character is that of a "strong and self reliant man of solitary habits of thought and untiring industry."

The results of Napier's mathematical researches were embodied in three publications, usually referred to as the *Descriptio*, 1614, the *Rabdologia*, 1617, and the *Constructio*, 1619, (a posthumous volume).

The *Rabdologia* is evidence of his love for practicality. Among other mathematical short cuts, it contains instructions for a rod for finding the product or quotient of two numbers mechanically, the device being still known as "Napier's bones." The modern slide rule is but an adaptation of the rods; some of the formulae he propounded are still used. The *Rabdologia* also contained a chapter on the decimal system, in which the use of the decimal point is recommended.

The *Mirifici Logarithorum Canonis Descriptio* contained Napier's logarithmic tables, with only as much description as was necessary to make their use clear. The *Mirifici Logarithorum Canonis Constructio*, though it bears evidence of having been written before the *Descriptio*, was not published till later because Napier wished to see how the logarithms were to be re-

ceived before he set forth the exposition of their nature and method of calculation.

Napier first called his logarithms "numerus artificialis," later making up the term "logarithmus" from the Greek λογος, ratio, and ἀριθμός, number. In his discussion he continually refers to the logarithms of sines, though he clearly states their applicability to all numbers and every sort of calculation. Probably therefore his original idea of them was merely as a means of shortening work with sines, and only after the work was well under way did he realize their general applicability. His definition and conception of a logarithm is a curiously complex and interesting one. About as concise a mathematical exposition as it is possible to make of his theory is found in Hobson's book.[1] He made use of the notion of continuously changing velocity, in handling which he came very close to the methods upon which Newton based his calculus fifty years later. Never having heard of an exponent, he had no conception of the base of a system, as such, but he realized an arbitrary element which made possible a variety of systems. He himself took the log sin 60^0 to be 0 and the log sin 0^0 to be infinity. This gave him a system in which the logarithms decreased as the sines increased, and consequently his logarithms were not the natural or so called "Naperian" logarithms at all. In the *Constructio*, Napier gives several methods for calculating logarithms for the tables, all of which involve an immense amount of work.

The appearance of the *Descriptio* in 1614 caused great excitement. Its value was immediately recognized on all sides. Kepler was enthusiastic in its praise. Edward Wright, a fellow at Caius College, Cambridge, immediately saw the use of logarithms in nautical calculation and made an authorized translation of the volume into English. Kepler translated it into German in 1625 and 1629, Cavalieri into Italian in 1624 and Edmund Wingate into French in 1626. One of the men most interested in the work was Henry Briggs, professor of Mathematics at Gresham College in London. In a letter dated March 10, 1615, he says "Napper, Lord of Markinston hath set my head and hands at work with his new and admirable logs. I hope to see him this summer, if it please God, for I never saw book which pleased me better or made me more wonder. I purpose to discourse with him concerning eclipses, for what is

[1]Hobson, *John Napier and the Invention of Logarithms*, Cambridge: University Press, 1914.

there that we may not hope for at his hands." Briggs did go to see Napier that summer, and suggested to him that the logarithms could be made more useful for calculation if they were allowed to increase with the numbers. His proposal was to allow log 1 to equal 0 and log 10 equal 1. Napier, in the *Descriptio*, had mentioned the possibility of a similar change. Between them that summer they settled on a new system, and during the next few years, Briggs devoted himself to calculating the new tables. He calculated to 14 decimal places the logarithms of all the numbers from 1 to 20,000 and from 90,000 to 100,000. These tables were published under the title "*Arithmetica Logarithmica*," in 1624. Adrian Vlacq, a Dutch bookseller, filled in the remainder of the table and published it in 1628.

The credit for the change to the base 10 must be shared between Napier and Briggs. Some writers, most of them following Hutton,[2] seem to take the view that Napier was trying to keep from Briggs credit that was due him, while Mark Napier on the other hand would reduce Briggs to the role of a mere calculator. Reference to the statements made by the men themselves settles the point, by showing exactly the part each played. Briggs says in the "*Arithmetica Logarithmica*," 1624,

"I myself when expounding publicly in London their doctrine to my auditors in Gresham College remarked that it would be much more convenient that 0 should stand for the logarithm of the whole sine, as in the Canon Mirificus, but that the logarithm of the tenth part of the whole sine, that is to say, 5 degrees 44 minutes 21 seconds should be 10,000,000,000. Concerning that matter I wrote immediately to the author himself; and as soon as the season of the year and the vacation time of my public duties of instruction permitted, I took journey to Edinburg, where, being most hospitably received by him, I lingered for a whole month. But as we held discourse concerning this change in the system of logarithms, he said that for a long time he had been sensible of the same thing, and had been anxious to accomplish it, but that he had published those he had already prepared, until he could construct tables more convenient, if other weighty matters and his frail health would permit him to so do. But he conceived that the change ought to be affected in this manner, that 0 should become the logarithm of unity and 10,000,000,000

[2]Hutton, Charles, *Mathematical Tables*.

that of the whole sine; which I could not but admit was by far the most convenient of all. So rejecting those which I had already prepared I commenced, under his encouraging counsel, to ponder seriously about the calculation of these tables."[3]

Napier in the *Rabdologia* in 1617 says:

"Of which logarithms, indeed, I have now found out another species much superior to the former, and intend, if God shall grant me longer life, and the possession of health, to make known the method of constructing, as well as the method of using them. But the actual computation of this new Canon, I have left, on account of the infirmity of my bodily health, to those versant in such studies, and especially to that truly most learned man, Henry Briggs, Public Professor of Geometry in London, my most beloved friend."[4]

The natural logarithms, now known as Naperian, were first introduced by John Speidell in 1619. Speidell, a teacher of mathematics, kept the general form of Napier's work, simply making the logarithms increase with the numbers in order that the tables might be used by any one who understood the arithmetical processes, without any knowledge of algebraic addition or subtraction. He had no thought of the theoretical value which has since been attached to the natural logarithms.

It is remarkable how little has been added to the subject since the work of Briggs and Vlacq was completed. Of course a great many tables have been calculated and recalculated. In 1875 there were 553 published tables ranging from 3 to 102 decimal places. Logarithms of the trigonometrical functions to the Briggian base were calculated very early by Edmund Gunter, a colleague of Briggs at Gresham College. Sang recalculated after methods of his own a complete table of logarithms to 17 decimal places of all numbers from 1 to 200,000. The most elaborate table of natural logarithms was published in 1778 by Wolfram. It contained the logarithms of the numbers from 1 to 10,000 calculated to 48 decimal places. In the course of the recalculations and revisions, the errors in the original tables have been weeded out. J. W. L. Glaisher in 1873 tabulated the number of mistakes occurring in some of the principal tables.

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[3]Quoted in Carslaw, *Royal Society of New South Wales, Journal and Proceedings*, 48:64.
[4]Ibid. 48:65.

His results are as follows:

Briggs	1628	171 (Due almost entirely to Vlacq)
Newton	1658	98
Gardiner	1742	19
Vega	1797	5
Callet	1855	2
Sang	1871	2

After the work of calculation had been done, various shorter methods were discovered, the infinite series for log $(1+x)$ whereby logarithms in the neighborhood of a known one may be easily and accurately calculated being one of the most important.

The science of logarithms, then, emerged suddenly from total oblivion into a condition so near perfection that three hundred years have been able to add but little to the results published in 1614. And the contents of the *Descriptio* have not only proved a mathematical tool of unlimited usefulness, but have also fitted into the development of theory in several branches of mathematics. Napier's ideas give hints of conceptions far in advance of his time. What he might have accomplished had he lived in a day when he was less handicapped by awkward systems of notation, it is interesting to speculate upon.

In spite, however, of the nicety with which Napier's theories have fitted into theoretical development of mathematical science, there can be no doubt that the sheer practical usefulness of the invention itself has been of more importance to the world. Cajori says that the power of modern calculation is due to three things: Hindu notation, decimal fractions, and logarithms. Hobson goes further and says that in importance to arithmetical work the invention of logarithms is second only to the introduction of the Indian number system. These are strong statements, but they have been justified in the past and they will be justified in the future. Imagine the time that would be wasted if our business houses had to use clumsy Roman numerals in their accounting. Scientific investigations and applications would be as badly off without logarithms.

The University of Michigan department of engineering research has entered into a contract with a trust company whereby university engineers will make searching analyses of the present and future possibilities of corporations or individuals to determine the soundness of the industries issuing certificates for sale to the public.

HISTORY OF THE BIOLOGICAL SCIENCES IN SECONDARY SCHOOLS OF THE UNITED STATES.

By George E. Nelson,
College of the City of New York.

(Concluded from January)

A leading position in the preparation of students for college has been acquired by the high school only recently. As late as 1872, 30 per cent of those entering college were graduates from high school, and 70 per cent were graduates from academies. The University of Michigan accepted botany and zoology as subjects acceptable for entrance credit in 1873. Harvard required either botany, or chemistry and physics or astronomy in 1876.

Beginning about 1870 zoology teaching adopted a new fashion which continued for about fifteen years. A comparative anatomy type of course was offered and the statements of the text were verified by means of specimens. The course still served to inculcate religious ideals. In the zoology course not as much importance was attached to natural history as had been done previously. Morphology was becoming increasingly important. Instead of beginning the course with classification, the various animals were considered in detail. Then they were classified by the students who now knew something about them. The order of study was also reversed as a result ofa better knowledge of the lower forms of life. Although Darwin's theory of evolution was also largely responsible for this reversed order of study, no direct effort was made to teach evolution. Louis Agassiz, however, was at this time the most potent factor in the reorganization of the course, for he was in America while Darwin was in England. Careful observation to find "natural affinities" became the leading aim of zoological study.

Some of the zoology books of this period are: Morse: First Book of Zoology—1875; Orton: Comparative Zoology—1876; Holder: Elements of Zoology—1884; Nicholson: Text Book of Zoology—1885; Packard: First Lessons in Zoology—1886; Colton: Practical Zoology. Colton's book was the first definite attempt to survey the whole animal kingdom by means of selected types. It was followed by an avalanche of laboratory manuals and a new idea was enthusiastically adopted. The student was to see for himself and make careful drawings from

the specimens. Observation and investigation were the methods to be employed. This book revolutionized zoology teaching and was the leading text until Boyer's "Laboratory Manual in Elementary Biology" came along. The latter expanded Colton's idea and included both zoology and botany in one year course. Wood and Steele's Fourteen Weeks in Botany, published in 1879 was very popular. Although Asa Gray's "How Plants Grow" was published in 1858, it was one of the best botany books of the period. The study of plants for the purpose of classification met with a reaction when many objected to Darwin's views concerning evolution. Parts of texts referring to evolution were frequently deleted. The botany course became chiefly a disciplinary subject. Laboratory hours were increased to about twelve per week (1890) so that many carefully labelled drawings could be made by the student. Real laboratory work in zoology began about 1885. The same comparative anatomy type of course was employed. The deluge of laboratory manuals continued until 1900 when the market became so saturated with them that it seemed that they would never be disposed of.

An interesting example of how public opinion, as represented by many organizations, can influence the teaching in schools is given in Finley's "Biological Sciences in the High School" page 13. The introduction into physiology texts of material concerning alcohol and narcotics was brought about by various groups of interests, especially the Temperance Unions; which endorsed texts containing such material.

Wherever biology was taught in high schools, however, it was done inadequately. The courses were of too short duration for the students to derive any appreciable benefit from them and the instructors were poorly trained in their subject. That this condition became evident to both students and teachers is certain, for there was dissatisfaction with the biology course and the method of teaching it. The first definite suggestion came from the Committee of Ten which was appointed by the National Educational Association.

In the Committee's report published in 1893 the conclusion is reached that science courses extending through one year be given in place of the half-year courses as formerly, that either botany or zoology be given, that the course should be a study of minute anatomy and classification and that in the study of the plant as much of the life cycle be studied as possible. It was recommended that physiology be postponed until the latter years

of the high school course. The actual statement of the committee is now given: "Resolved, that it is the judgment of the conference that, while the principles of hygiene should be included in the work of the lower grades, the study of physiology as a science may best be pursued in the latter years of the high school course. We recommend that in the high school a daily period, for one year, be devoted to the study of anatomy, physiology and hygiene with as large an amount of practical work as it is possible.

That the study of natural history (botany and zoology) should begin in the primary schools at the beginning of the school course.

That no less than one hour per week, divided into at least two periods, should be devoted throughout the whole course before the high school to the study of physiology and anatomy; that in this study no text book should be used, and that these observation lessons should be made the basis of, or correlated with, work in language, drawing and literature.

That a minimum of one year's study of natural history should be required in every course in the high school, and that at least three-fifths of the time should be employed in laboratory work.

That the general comparative morphology of physiology and anatomy be recommended as the part of the natural history most suitable for study in the secondary schools; that in the primary and grammar grades there should be a study of gross anatomy, and in the secondary schools a study of minute anatomy.

That the year's work in natural history, as outlined for the high school, should be required for entrance to college in every course; that the examination should be both a written test and a laboratory test, and that the laboratory note books, covering the year's work, certified by the teacher as original should be required at the examination.

That differentiation appears to be unwise and therefore not desirable.

That the study of natural history in both the elementary and the high school should be by direct observational study with the specimens in the hands of each pupil, and that in the work below the high schools no text book should be used.

That at least one fourth of the high school course should be devoted to nature studies; and that this amount of preparation should be required for entrance to college."[1]

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[1]U. S. Bureau of Ed. No. 205, Report of Committee on Secondary School Studies 1893, pp. 138-141. Also Am. Book Co.

Although N. T. Harris, Commissioner of Education, asserted that this was one of the most important documents ever issued in the United States, it did not have a great influence. E. G. Dexter in a study of the influence of this report made ten years after its publication found no improvement in the situation. He analyzed every available course of study in 1894 and 1904. He found this situation:

	Botany	Zoology	Botany and Zoology
1894	48%	9%	43%
1904	30%	6%	64%[2]

Inglis in a discussion of the reasons for the lack of acceptance of the report gives these reasons:

(1). The committee failed to arrange the work so as to meet the needs of the pupils who left school before the close of the course.

(2). Its recommendations tended to organize the study of natural sciences in terms of subject matter instead of the subject matter in terms of the capacities of the pupils and their later needs.

(3). It supported the study of several natural sciences which were of questionable value (in a relative sense) in a secondary school and which were discarded in later development, at least as separate subjects of study; e. g. astronomy, geology, meteorology.

(4). It failed to recognize the need of relating the study of natural sciences more directly to life, especially with reference to vocations.[3]

The Committee of Ten consisted of five college or university men, three men from the high schools, one from a normal school and one superintendent. Moreover, the report tended to standardize the sciences to be studied and their sequence in the course. It emphasized the need for some natural science for every pupil and placed emphasis on laboratory work. That there was a reaction to the method of science teaching is evident in the preface of Martin's Human Body, a physiology text in common usage at the time. He says, "that some instruction in at least one branch of natural science should form a part of the regular edu-

[2]Dexter, E. G. "Ten Years' Influence of the Report of the Committee of Ten," School of Review, XIV, 254-269, 1906.

[3]Inglis, A. "Principles of Secondary Education." Houghton, 1918, pp. 508.

cational curriculum is now so generally admitted that there is no need to insist upon it. If instruction means teaching by rote, however, the function of natural science is missed."[4] These and other suggestions as to the duration of the course and the method of teaching were not sufficient. Some degree of standardization of the content of the courses themselves was necessary.

Bergen's Elements of Botany appeared in 1896 and in 1900 Parker and Haswell's Manual of Zoology was published. These books deserved the popularity that they enjoyed and are still being employed today. They have been adopted as text books both in high school and college courses which is evidence of their thorough treatment of the subject.

Zoologists and botanists were not satisfied with the dispensation of their subject by the Committee of Ten, and after some agitation and pressure they contrived to have biology given a better position when the Committee on College Entrance Requirements reported in 1896. The committee recommended that in the second year biology or botany or zoology be given, or else botany and zoology as two half courses. The committee also stipulated that these are proper and acceptable for college entrance.

The education periodicals of this period are replete with suggestions concerning the biology course. H. B. Ward in the proceedings of the National Educational Association, 1897, stresses the need for zoology, the importance of laboratory work and excursions. He calls special attention to the value of the careful drawings in the laboratory and says that training in the other sciences is not a prerequisite for an elementary course in zoology. The Regents' Report in 1900 has the statement that biology should be one of the four years of science courses and that both plants and animals should be considered. Bigelow, about 1904, recommends a course in zoology or in the principles of biology during the third or fourth years of high school. He also says that nature study should be given in elementary school, one year of physiology in the eighth grade or if no laboratory facilities are available, postponed to the first year of the high school. The American Society of Zoologists in 1903 appointed a committee of five to consider the question of a college entrance option in zoology as considered from the viewpoint of the high school.

Frances Lloyd in a Regents' Report in 1901 sets his requirements as to a suitable preparation for secondary teachers in biology. He says, "a biology teacher should have nine points of

[4]Martin: Human Physiology, 1894.

undergraduate study of biology, of which three should be either botany or zoology. The work in biology should be buttressed by thorough work in physics and chemistry. During the senior year in college a course in the history of education, principles of education, and the theory and practice of secondary teaching should be taken. Thus, at this early date we have the need for some pedagogical training for the biology teacher recognized.

The acceptance of biology as a college entrance requirement was considerably influenced by the publication of a pamphlet by Harvard University called an "Outline of Requirements." It was intended for use in preparing students for the Lawrence Scientific School. It appeared in 1898 and was first clear suggestion for the differentiation of the high school and college course in biology and zoology. The course outlined was an attempt to restore the old time instruction in natural history to the secondary schools and to leave the science for the first year college course. This pamphlet was widespread and led to recognition of natural history as a proper secondary school subject and also a college entrance credit course. Other recommendations concerning biology as a college entrance course came from C. B. Davenport in a report to the Regents in 1898, "Zoology as Condition for Admission to College" and W. F. Ganong "Suggestions for an Attempt to Secure a Standard College Entrance Option in Botany" which was published in Science in 1901. H. L. Osborn also contributed with "Differentiation of Zoology for the High School and College" in the School Review, 1901.

About 1900 the comparative anatomy type of zoology course was tempered by the addition of material of the natural history sort. The field was again visited and live specimens studied. The doctrine of evolution began to penetrate into high school biology. In 1904 a revision of Bergen's Botany appeared that treated the subject from an ecological point of view. Plant physiology and the economic importance of plants received attention. Life histories of forms were studied as examples of physiological reactions to the environment. Some of the Zoology texts are: Davenport: Introduction to Zoology; Kellogg: The Animals and Man, Text Book of Zoology.

In 1900 the College Entrance Board was organized as the result of ten years of constant activity on the part of committees and educators who were endeavoring to formulate definite standards in the teaching of biology. Its purpose was to standardize the curricula and develop courses of study.

In New York State the laws of 1877, Chapter 425, required that the Board of Regents establish academic examinations for the secondary schools. Before this could be done some method of delimiting the subjects in which the students would be examined was necessary. This was accomplished by the formal syllabus which was first distributed in 1880. Subsequent editions appeared in 1882, 1888, 1895, 1900, 1905, 1910.

In the 1905 syllabus it was recommended that all schools have adequate laboratory equipment and teachers of requisite scientific training give a first year course in biology consisting of some study of botany, zoology and human physiology. The reasons given were that the interests of students are extensive rather than intensive, and that the essentials of life phenomena require study of both plants and animals. A minimum of thirty lessons in human physiology was required during the first year. However, in high schools unprepared to teach such a course, a half year course in either botany or zoology might be given. Botany was to precede zoology and physiology because material for plant study could be obtained at any time of the year and there was less objection on the part of the student when a beginning was made with plants. In addition human physiology treats of the most specialized type of life and should therefore be considered last in the course. Courses of study for biological science, elementary botany, elementary zoology, advanced botany, advanced zoology, physiology and hygiene were given in detail in this syllabus. Jordan and Kellogg's "Animal Life," published in 1900, was used a great deal. This book attempted to restore the natural history viewpoint to the subject as well as to organize the course about such topics as the struggle for existence, adaptations, protective resemblance, mimicry, etc. The structural point of view was employed and considerable attention given to the function of the parts and the life history of the organisms. After 1900 both botany and zoology were subjects primarily interested in principles and not in things.

In 1910 the New York syllabus sought to unify the course by selecting and emphasizing those topics which are of general biological importance. The aims of the biology course were:

(1) First hand knowledge of common plants and animals.

(2) Some understanding of essential functions carried on by living things.

(3) Economic importance of plants and animals.

(4) Individual and public health.

The practical point of view was well represented by the numerous texts appearing with the title "Practical" or "Economic." Bergen and Caldwell's Practical Botany, 1911, was and is still the most popular book of its type. Zoology texts were also written from the same viewpoint, Hegner's Practical Zoology and Kellogg and Doane's Economic Zoology being typical for that subject. In 1910 J. P. Gilbert performed an experiment to compare the results secured by employing the economic vs. the scientific approach to the biology course. While his results cannot be interpreted as offering a solution to the problem of the relative merits of the two methods, it suggests that the economic or practical approach usually achieves better results.

In 1916 President Eliot called attention to the slight extent to which sensory training was developed in our schools. He suggested that more of it be included all the way through elementary and high school. Biology, chemistry and physics, were the subjects he recommended to supply this training.

In 1920 a course of study in Nature and Environment was adopted by the Board of Superintendents of New York City. Elementary biology appears in 9A-9B. For this course the chief aims are to study living things, the ways in which organisms maintain life, the interrelationships of organisms and groups of organisms, the relationship between the living and non-living world and man's control of plants and animals for his own needs.

In 1920 the National Education Association appointed a committee to reorganize the science curriculum. The results achieved by a member of experimental schools, the experience of science teachers and the judgments of educational experts served as criteria for the reorganization of the course both in content and method. The cardinal aims of biology were considered to be represented in the development of: (1) Health. (2) Command of fundamental processes. (3) Worthy home membership. (4) Vocational interest. (5) Citizenship. (6) Leisure time. (7) Ethical character.

At a high school conference which convened at the University of Illinois the following aims were thought to be the most important:

(1) To give the student a vital interest in plants and animals.

(2) To show the human values of plants and animals.

(3) To form a problem solving habit concerning plants and animals.

(4) To develop some ability in the use of the library, field and laboratory.

(5) To be able to sustain interest in plants and animals over long periods.

(6) To show the effect of response to environment (adaptation).

(7) To give some conception of evolutionary sequence.

(8) To give some experience in the classification of organisms.

(9) To have an open-minded view towards evolution.

(10) Sex education.

Another recent list of aims for high school biology is the result of a questionnaire. This is reported in SCHOOL SCIENCE AND MATHEMATICS, March 1923, page 258. The aims in order of greatest frequency are:

(1) To train in accurate observation.

(2) To reason.

(3) Biology as a leisure study.

(4) To study the environment biologically.

(5) To know one's body by a study of plants and animals.

(6) Citizenship.

(7) Civic biology.

The aims of biology from these three sources are largely subjective and their utter lack of agreement is not remarkable. It seems that some objective measure of social utility would be a better criterion from which to derive clearly defined and workable objectives. Bobbitt has taken us a step in that direction by analyzing the activities that an individual normally engages in. Considering the function of education to be an attempt to aid the individual in executing certain activities successfully or more efficiently he has arrived at a number of definite and tangible objectives for biology. These are the acquisition of such skills, attitudes and activities in biology as will best promote the general interests and activities of the individual.

During the last ten years a new type of biology course has become popular. The content is not treated as that of two distinct sciences—botany and zoology, but the two are integrated—such material being selected from either the plant or animal kingdom as will best demonstrate the fundamental characteristics of living organisms and the generalizations of biology. This biology course is being reorganized at the present time. Reuser's "The Status of General Biology in the High Schools of

the North Central States" and O. W. Richards in "Present Status of High School Biology" are representative investigations concerning the nature of the current biology course. The results of both of these studies illustrate the great variety of content offered and the lack of any standardization.

Several important studies of the content of biology courses have also been made recently. S. G. Rich's "Analysis of Current Examinations in High School Biology," O. W. Richards "Present Content of Biology in Secondary Schools" and Ruch-Cossman's "Standardized Content in Biology," further illustrate the prevailing divergent ideas concerning the materials of the biology curriculum. G. W. Hunter's "One Year Fundamental Course in Biological Science" considers the desirability of determining a certain minimum standard of content in the biology course. Surely there are a great many elements of biological knowledge of such importance that they can not be omitted from any secondary school biology course. Although complete standardization may be undesirable it surely would promote better teaching if we will adopt a certain minimum care of content.

The fact that nearly all of the recent high school texts deal with general biology while there have been practically no new high school texts in botany or zoology for the last ten years, and the fact that the botany and zoological registration have dwindled, seems to indicate that general biology will have a permanent place. Some of the new texts are:

Clement—Living Things, 1924.
Smallwood—Reveley and Bailey—New Biology, 1924.
Moon—Biology for Beginners, 1925.
Bigelow—Introduction to Biology, 1922.
Gruenberg—Biology and Human Life, 1925.
Hunter—New Essentials, 1923.
Peabody and Hunt—Biology and Human Welfare, 1924.
Kinsey—Introduction to Biology, 1926.
Waggoner—Modern Biology, 1926.
Atwood and Powers—General Biology, 1927.

Some of these texts employ the practical approach—that is the various topics are introduced in problem form and they concern phenomena that are easily observed. The other—the scientific approach is a logical presentation of the various topics in a systematic order. All of the general biology texts consider man as the central theme. Man's control of nature, the evolutionary

process by means of which he came about, the influence of the environment upon his nature, are some of the principal topics considered.

The responsibility for the organization and character of the biology courses has in the past been almost entirely dependent upon the efforts and thought of those interested primarily in the content of biology. Today, a large number of investigators, who are not only competent to examine the content critically, but in addition have the knowledge and ability to employ quantitative measuring instruments are engaged in the task. Today, they are approaching the study from a psychological and sociological viewpoint which was unknown two decades ago. The mere rearrangement or reorganization of the biology course has not been a satisfactory solution of the problem of what content to include in a biology course that will most nearly achieve the objectives of education.

The dynamic character of life necessarily requires a periodical re-examination of the curriculum content if education is to keep in close contact with actual needs. Another important project is the determination of the extent to which these materials are mastered. For this purpose objective tests, which are superior in almost every qualification to the old essay type of examination are being employed. N. M. Grier's range of information tests in Zoology, Botany and Physiology were the pioneer attempts in this field. They have been superseded by Downing's range of information tests. Among the more comprehensive objective biology examinations there are the Cooprider and Ruch-Cossman tests. These tests measure the extent to which facts have been learned. Tests that will determine the extent to which scientific attitudes are developed have not been produced as yet. The psychologist will probably have to contribute to their creation.

With the adoption of a course in which the materials are organized about certain topics, and wherein laboratory is not required to such a great extent as in the previous type of course; there has been some question as to the importance of laboratory work. There are so many factors involved in experiments relating to the laboratory that few definite conclusions can be validly drawn at this time concerning the merit of these experiments. If information is the desired objective of laboratory work, lecture-demonstration methods show slightly better results when the students are tested immediately after the experiments. When

the testing is repeated some time later the individual-laboratory group achieves higher results than the other group. Individual laboratory methods are superior to lecture-demonstration methods in that other important values are obtained in addition to information. Probably the best results will be obtained by the judicious use of both methods, some experiments being done by one and the others by the alternative method. The selection of the method will depend upon the nature of the experiment itself and the objectives that are set for it.

In Finley's "Biological Sciences in the High School" there is given on page 29 a tabular summary of seven investigations concerning the sequence of the biological sciences. General science which consists of approximately 27 per cent of biology, according to the estimates of S. R. Powers is found in the 9th grade while physiology is usually found in the same grade. Biology, botany and zoology usually are tenth grade subjects. It is evident that biology has definitely assumed a position in the 10th grade.

These sequences are the result of many forces that have been operating during the last twenty-five years. All the sciences have become increasingly specialized during this period so that many now require special techniques or mastery of fundamental material before they can be studied. It has been impossible for a student to master all the sciences with such a phenomenal growth of the material to be studied. Consequently either of several things had to be done—the number of science studies reduced, the various courses simplified, or a general course offered with a selected content.

Various schools have attempted to employ these solutions for the dilemma and texts reveal a similar reaction. For example, Hunter's Biology has three chapters of introductory material before biology is treated at all. The departure from the strictly scientific organization of the subject to a topical treatment is also a device for covering the field extensively, although it is not the only reason for such an arrangement.

The reorganization committee of the N. E. A. which in 1920 recommended a definite science sequence for schools according to their size, suggested that biological sciences be given in the 9th year of the Junior-Senior High School or in the second year of a four year High School. No statement was made as to the kind of course, however, general biology, botany and zoology being regarded as of equal value.

Reports of committees, scientific investigations and the expression of public opinion have not been the only standardizing influences. The changing character of the student body, both quantitatively and qualitatively, must be recognized in the reconstruction of the biology course. In 1870 five per cent of the elementary school pupils passed from the 8th grade into high school while in 1918 thirty-six percent did so. In 1870 only one per cent remained until the close of the high school course while in 1918 fourteen per cent completed the course. In this larger high school group, there is present a much wider range of mental ability as well as more varied interests. The high school course in biology must be adjusted to these changed conditions.

Remarkable as has been the progressive trend in the teaching of biology many fundamental problems remain to be solved. A continuous biological program through the secondary school and junior college remains to be worked out. Materials for the various biology courses should be selected from a functional viewpoint, only those topics being included which have utility and actually lead to the realization of a specific objective. Laboratory exercises should be examined and objectives defined for each of them. Experimentation will decide whether the lecture-demonstration or individual laboratory methods should be employed in obtaining the appropriate values from each experiment. The adjustment of course content to present social needs has only been accomplished in a superficial manner. An intensive analysis of contemporary American problems and social forces is an essential factor in the reconstruction of the course. Caldwell and Finley's analysis of newspaper articles dealing with biological subjects, Hockett and Rugg's list of social concepts necessary for intelligent reading, Harap's objectives in "Education for the Consumer," are some of the criteria which might be employed in the reconstruction of the biology course

The teaching of biology has recently been confronted with a reaction similar to that of the period about 1870 when many texts had pages relating to evolution deleted from them. The first definite maneuver against the teaching of evolution came from Governor Peary of Tennessee, who in March 1925 signed the first state anti-evolution law in America. This law stated that it is a criminal offense to advocate in public schools and colleges "any theory that denies the story of the divine creation of man as taught in the Bible and teaches instead that man descended from a lower form of animal. It has been predicted

that this movement will spread to fifteen or twenty other states. During the early part of 1926 three anti-evolution bills were introduced into State Legislatures. Mississippi has enacted an anti-evolution law, Kentucky passed a bill through the lower house of its State's Legislature but it was defeated in the upper house. Virginia attempted to pass a bill but later decided to withdraw it and Georgia has been actively working for an anti-evolution law. In Texas, the public school books have been purged of all reference to the descent of man and in California the State Board of Education has decided that if evolution is expounded at all, it should be "merely as a theory." The Fundamentalists in Kansas have classified evolution as a "type of religion" and attempts are being made to enact laws against the teaching of it.

These reactionary forces will not be without opposition, however, when they attempt to extend their field of operations. The American Association of University Professors has begun to organize all the other groups which oppose the extention of medieval legislation which is a disgrace to any modern nation.

SEEK RUBBER PLANTS.

Backed by Thomas Edison, a quiet two-man rubber exploration of the semi-arid lands in southwestern Texas and the adjacent territory in Mexico has been carried on during the past few weeks. Dr. J. N. Rose, of the U. S. National Herbarium, and Paul J. Russell, of the U. S. Department of Agriculture, were the personnel of the expedition, and they have brought back to Washington a number of specimens of plants suspected of rubber-yielding possibilities.

"The plants I paid most attention to were those belonging to the milkweed and euphorbia or spurge families," said Dr. Rose. "The milkweeds have long been known to have rubber in their milky juice, but so far it has not been found in paying quantities. The euphorbias include such familiar plants as the Christmas thorn and the poinsettia, and are somewhat more distantly related to the Hevea, or Para rubber tree, now the chief source of our rubber.

"The most promising species I found was one member of the euphorbia group. A rough analysis of its latex, made by a local chemist, indicated a rubber content of nine per cent. Whether this will be confirmed by more careful examinations in specially equipped laboratories I have, of course, no way of knowing just yet.

"Of course, sensational promises of great rubber plantations in Texas would be nothing but pipe dreams. Mr. Edison has made it quite plain, I believe, that what he has in mind in his present program is the development of a potential emergency supply, which could be drawn upon if a war or other calamity should cut us off from the cheaper rubber of the tropics."

The Mexican part of Dr. Rose's expedition took him south along the Gulf coast for about a hundred miles beyond the border. This was during the time of the recent abortive revolution; but Dr. Rose reports that this part of Mexico was not affected by the uprising, and that in any case most of the region was uninhabited.—*Science News-Letter.*

LINEAR AND ANGULAR VELOCITIES AS VECTOR QUANTITIES.

By N. F. Smith,

The Citadel, Charleston, S. C.

The average student of mechanics has little difficulty with the concepts involved in the composition and resolution of linear velocities. This is doubtless due to the fact that, either consciously or unconsciously, he thinks of the linear velocities as actual displacements taking place in unit time in the directions of the different vectors. The application of the principles of the composition and resolution of vectors to angular velocities about intersecting axes is one of the most difficult problems which the student encounters in mechanics. This difficulty is largely due to the fact that the vectors by which the angular velocities are represented do not represent actual displacements of any particle in the body. Some physics texts (e. g. Ferry, page 62) give a geometrical proof of the fact that the parallelogram law holds good when applied to angular velocities, but the average student while following the mathematical analysis, has difficulty in visualizing the different rotations involved.

The student readily conceives that a body may have imparted to it simultaneously two independent linear velocities along intersecting lines. He thinks, for example, of a man walking on the deck of a ship while the ship moves in a different direction upon the surface of the water, and he perceives that the actual velocity of the man, with reference to the surface of the water, is correctly represented by the customary vector addition. Or he perceives, with little greater difficulty, that a ball thrown into the air has, at a given instant a velocity which may be thought of as a certain rate of motion in a vertical direction and a certain rate of motion horizontally. What we sometimes fail to emphasize, both in thinking and in teaching, is the fact that, in both of these cases, the body is not moving in two different directions at the same time, and that the parallelogram law is arrived at by applying the method of limits to infinitesimal displacements taking place successively,—not simultaneously,—in the different directions.

Emphasis of these facts will aid the student in understanding more readily that a rigid body may have imparted to it simultaneously two rotations about intersecting axes, and that the resultant motion is an angular velocity about a third axis

whose value, in direction and magnitude, is equal to the vector sum of the components. Here it is important to point out that the three axes must always lie in the same plane, and that, while the axes of the two component rotations are *fixed in the body*, they are *not fixed in space*. This answers the question, so often asked, "How can a body rotate about two fixed axes?" At this point a simple mechanical model, such as that shown in Figure 1, will be found of the greatest help. A block of wood

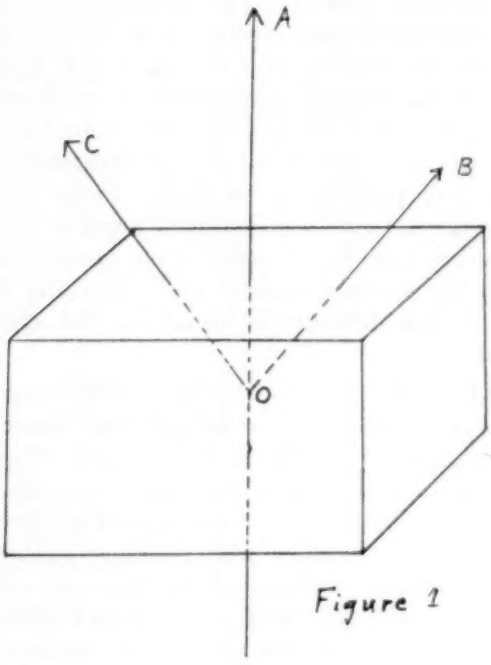

Figure 1

or a cake of soap is provided with three intersecting axes made from knitting needles, OA, OB, and OC. Just as we think, in the corresponding case of the composition of linear velocities, of small component displacements taking place *successively*, so here let us apply small angular displacements in succession about the axes OB and OC. First hold OB in a suitable clamp and rotate the body about this axis through a small angle, θ_1, (Figure 2) in the direction indicated by the arrow on the axis (vector) OB. This will bring OC into the position OC′, and OA to OA′. Now release the clamp from OB, and clamp OC in its new position OC′, and give the body a rotation θ_2, about OC. The

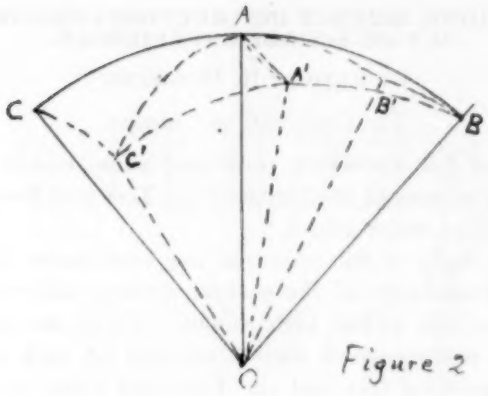

Figure 2

axis OB moves to the position OB′, and OA′ moves back *to its original position*, OA. Thus the effect of the two small angular displacements applied successively about the axes OB and OC is the same as that produced by a single rotation about OA, bringing the other two axes into the new positions OB′ and OC′, respectively. It is easy to see that this reasoning will hold true if the displacements are made infinitely small and the rotations are made continuous.

By a reversal of the process we may think of the rotation of such a body as the earth about its polar axis as made up of two rotations, one about a vertical axis through the place of observation, and the other about a vertical axis at right angles to the former. In the well known Foucault pendulum experiment, the plane of vibration of the pendulum is unaffected by the latter component, while it rotates about a vertical axis with the angular velocity of the former of the two component rotations. It is readily seen that the angular velocity of this component is proportional to the sine of the angle of latitude of the place. Hence the period of the rotation of the earth upon its polar axis is equal to the period of rotation of the plane of vibration of the Foucault pendulum multiplied by the sine of the angle of latitude of the place where the observation is made.

University students from England and Scotland, to the number of nearly 100, worked during the busy harvest season this fall on farms in western Canada. In addition to the travel and agricultural experience gained, earnings of the students almost entirely met the expenses of the trip.

HIGH SCHOOL SCIENCE INSTRUCTION COMPARED TO OUT-OF-SCHOOL EXPERIENCES.

By Elliott R. Downing,

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The author has elsewhere published some results from the study of the returns of the Group Four Test and from the individual tests that enter into it.*

A further study of this material has been made to see what increase in knowledge of the several science subjects is shown from year to year of the high school. There are given tables showing the percentage of correct answers for each question of both the Five-word test and the True and False test, for each year of the high school. The figures are average grades for 1237 freshmen, 685 sophomores, 735 juniors and 470 seniors in six Chicago and two Toledo high schools. (Except for questions 7, 8, and 9 of the True-false test in which cases the number of students for the four years are respectively 1047, 482, 435, 244.)

Percent of Correct Answers of Questions 1-16 in Five Word Test For Each Year of the High School.

The subject matter dealt with in each question is indicated by the following: B, Biology; Biog., Biography; C, Chemistry; P, Physics; P. G., Phys. Geography; Phys., Physiology.

Nature of Subject Matter and Question Number.

	Phys.	B	P.G.	Phys.	Biog.	P.G.	B	P	Phys.
	1	2	3	4	5	6	7	8	9
	%	%	%	%	%	%	%	%	%
Fresh	41.6	19.5	12.6	63.9	7.6	19.2	29.3	83.0	13.4
Soph	42.9	31.7	10.1	59.4	20.9	23.9	37.2	83.9	14.3
Jun	40.3	32.9	14.3	71.8	46.9	20.7	44.5	87.2	18.6
Sen	45.5	30.0	13.6	67.8	60.6	22.1	46.8	86.6	22.3

Question No.	Biog.	C	B	B	C	B	P
	10	11	12	13	14	15	16
	%	%	%	%	%	%	%
	8.8	7.3	0.5	29.9	17.6	22.9	4.2
	9.6	6.1	7.1	64.5	14.6	45.0	5.7
	15.2	15.2	4.6	52.3	35.0	35.4	15.2
	17.2	21.1	4.0	59.0	53.8	35.0	23.2

The percentage of correct answers for the questions dealing with physiology, physics, physical geography, biology, and chemistry have been separately added and averaged for each year, the freshman, sophomore, junior and senior. The percent gained from year to year has then been calculated. The results are discussed below for each of the several sciences.

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*Revised Norms for the Range of Information Test in Science, School Science and Mathematics, vol. xxvi, pages 142-146.
Norms for the Group Four Test, Ibid, pp. 638-643.
Norms of Scientific Ability and Achievement in the High School, Ibid, pp. 717-721

PERCENT OF CORRECT ANSWERS OF QUESTIONS 1-33 IN TRUE FALSE TEST FOR EACH YEAR OF THE HIGH SCHOOL.

Question No.	Phys. 1	P.G. 2	P 3	P.G. 4	P 5	B 6	Phys. 7	B 8
	%	%	%	%	%	%	%	%
Fresh	51.8	58.6	52.0	46.5	36.6	35.2	73.2	61.7
Soph	57.8	57.5	48.2	45.5	38.0	49.2	82.2	69.3
Jun	52.4	59.2	55.2	42.9	41.5	41.1	72.4	55.6
Sen	66.8	63.2	60.9	50.2	56.2	43.4	70.1	68.0

Question No.	C 9	P 10	B 11	C 12	B 13	P.G. 14	B 15	P 16
	%	%	%	%	%	%	%	%
	29.0	28.4	10.1	25.6	54.6	32.9	12.0	23.8
	31.7	28.5	28.3	23.4	51.4	31.2	11.2	22.5
	31.7	34.3	20.3	35.1	57.8	26.8	10.2	21.9
	39.7	37.4	23.3	51.3	60.0	30.2	14.3	34.0

Question No.	B 17	B 18	P.G. 19	C 20	Phys. 21	P 22	B 23	C 24
	%	%	%	%	%	%	%	%
	71.6	33.5	28.9	11.3	47.4	44.3	44.1	15.4
	91.7	31.8	18.1	15.8	57.5	36.5	39.3	12.5
	86.8	23.8	15.0	19.6	48.0	43.4	29.9	18.5
	86.0	33.4	17.4	38.5	62.3	57.2	32.6	35.5

Phys. 25	P 26	P 27	P.G. 28	C 29	P 30	B 31	P.G. 32	B 33
%	%	%	%	%	%	%	%	%
66.5	38.8	23.1	47.8	45.0	13.2	21.8	71.1	25.2
62.5	19.7	17.4	39.0	53.7	10.7	17.7	57.4	26.7
64.4	19.9	18.6	43.3	48.6	21.0	10.5	61.6	26.9
71.3	32.3	21.9	44.3	61.1	35.1	16.6	71.7	27.4

Questions 3 and 6 of the five-word test and questions 2, 4, 14, 19, 28 and 32 of the true-false test deal with physical geography. This subject matter, if occurring anywhere in the present science course, would probably come in the general science given in the freshman year. If we add together the percentages of correct answers on these eight questions, we find that for the freshman year the total is 317.6, sophomore 282.7, junior 283.8, senior 312.7. The freshmen, it will be noted, have a higher total score on these questions than do the pupils of any other year. Apparently we must conclude, therefore, that this subject matter is acquired in the freshman year to some extent at least and is not picked up very extensively through out-of-school sources. The average loss per question between the freshman and the sophomore years is 4.36%. From sophomore to junior year, there is an average gain per question of 0.14% and from junior to senior year an average gain of 3.62%. Between the freshman and senior years there is an average loss per question of 0.62%.

Questions 1, 4, 9 in the five-word test and questions 1, 7, 21, and 25 of the true-false test deal primarily with the subject mat-

ter of physiology. The total score on these seven questions for the freshmen is 357.8, sophomores 376.6, juniors 367.9, seniors 406.1. The average gain per question from freshman to sophomore year is 2.69%; between the sophomore and junior year there is a loss per question of 1.24% from the junior to the senior year there is a gain per question of 5.46%. The total gain per question from the freshman to the senior year is 6.9%. One would expect the marked gain to come in the freshman and sophomore years since physiology customarily forms part of the general science course and also part of the biology course. We find, however, that the largest gain is in the junior to the senior year and must conclude therefore, that the instruction in physiology in the general science and biology courses is not very effective, at least, in as far as the principles involved in these questions is concerned.

Questions 2, 7, 12, 13 and 15 of the five-word test and in the true-false test questions 6, 8, 11, 13, 15, 17, 18, 23, 31 and 33 deal with biology. The total score on these fifteen questions is 471.9 for freshmen, 602.1 for sophomores, 535.3 for juniors, 579.8 for seniors. The greatest gain is made from the freshman to sophomore years, 8.8% per question. Between the sophomore and junior years there is a loss of 4.45% and between the junior and senior years a gain of 2.30%. The total gain from freshman to senior years per question is 7.19%. Biology is distinctly a sophomore subject and apparently the conclusion is justifiable that there is a marked effect in the student's ability to answer questions dealing with biology as a result of his schoolroom instruction in this subject. Since the total gain made by the sophomores is greater than that made during the entire high school course, the biology instruction in the high school is apparently a more important factor in the student's gain of biological information than are the out-of-school factors.

Questions 8 and 16 of the five-word test deal with physics as do also the following questions of the true-false test: 3, 5, 10, 16, 22, 26, 27, and 30. The total score on these ten questions for the freshmen is 347.4, sophomores 291.0, juniors 358.2, seniors 444.8. There is an average loss per question between the freshman and sophomore years of 5.64%, a gain from the sophomore to the junior year of 6.72%, and from the junior to the senior year of 8.66%. The total average gain from the freshman to senior year is 9.75%. The conclusions from these figures seem to be that the general science contributes considerably to the

pupil's understanding of the principles of physics, since the total score in the freshman year is higher than that in the sophomore year. There is a fairly marked gain both from the sophomore to the junior and from the junior to the senior years. In the schools from which the data were obtained, physics is a junior subject, though there were a good many seniors in the classes. Physics instruction for juniors and seniors contributes notably to their understanding of the subject.

Questions dealing with chemistry are 11 and 14 of the five-word test and in the true-false test 9, 12, 20, 24 and 29. The total scores on these seven questions for the freshmen is 151.2, sophomores 157.8, juniors 203.7, seniors 297.1. The average gain per question from freshman to sophomore year is 0.94%, from sophomore to junior year 6.56%, from junior to senior year 13.34%. One must conclude that the instruction given in chemistry is a very important factor in the acquisition of chemical knowledge on the part of the student. The gain made from the junior to the senior year when chemistry is ordinarily taken is greater than the gain to be attributed to the study of any other high school science, as far as the results of these tests are concerned. Apparently out-of-school contacts have little effect on the acquisition of chemical knowledge.

Two questions deal with biographical material, questions 5 and 10 in the five-word test. The former distinguishes a poet from a group of biologists, the latter a biologist from a group of physicists. The scores on these questions are readily seen from the tabulation above. Probably no conclusions are justifiable on the meager data.

Against this background of general performance on the test throw the work of two schools, a Chicago school which will be designated as No. 2 and a Toledo school, No. 1.

On the physical geography questions the average score for the eight questions is:

All freshmen	39.7; sophomores 35.3; juniors 35.5; seniors 39.1
Toledo 1, freshmen	45.1; sophomores 44.4; juniors 34.8; seniors 49.5
Chicago 2, freshmen	28.0; sophomores 28.3; juniors 27.5; seniors 29.7

Similarly on the seven physiology questions, the comparisons run:

All freshmen	51.1; sophomores 53.8; juniors 52.6; seniors 58.0
No. 1 freshmen	49.1; sophomores 59.0; juniors 50.0; seniors 61.7
No. 2 freshmen	49.0; sophomores 50.4; juniors 50.3; seniors 53.4

The corresponding figures for the fifteen biology questions follow:

All freshmen	31.5; sophomores 40.1; juniors 35.7; seniors 38.7
No. 1 freshmen	29.7; sophomores 43.0; juniors 30.4; seniors 36.5
No. 2 freshmen	31.4; sophomores 34.9; juniors 33.3; seniors 36.6

The ten questions in physics yield the following returns:

All freshmen	34.7; sophomores 29.1; juniors 35.8; seniors 44.5
No. 1 freshmen	34.4; sophomores 31.0; juniors 27.0; seniors 42.9
No. 2 freshmen	23.6; sophomores 31.3; juniors 31.4; seniors 38.1

Seven questions dealing with chemistry give these averages:

All freshmen	21.6; sophomores 22.5; juniors 29.1; seniors 42.4
No. 1 freshmen	20.7; sophomores 23.7; juniors 24.7; seniors 40.1
No. 2 freshmen	18.1; sophomores 17.1; juniors 23.8; seniors 42.5

The gains and losses for the several subjects and the three groups, all students, at Toledo School 1 and at Chicago School 2, are shown below.

PHYSICAL GEOGRAPHY.

	Fresh.-Soph.	Soph.-Jun.	Jun.-Senior
All Students	−4.4	+0.2	+ 3.6
Toledo 1	−0.7	−9.6	+14.7
Chicago 2	+0.3	−0.8	+ 2.2

PHYSIOLOGY.

	Fresh.-Soph.	Soph.-Jun.	Jun.-Senior
All Students	+2.7	−1.2	+ 5.4
Toledo 1	+9.9	−9.0	+11.7
Chicago 2	+1.4	−0.1	+ 3.1

BIOLOGY.

	Fresh.-Soph.	Soph.-Jun.	Jun.-Senior
All Students	+ 8.6	− 4.4	+3.0
Toledo 1	+13.3	−12.6	+6.1
Chicago 2	+ 3.5	− 1.6	+3.3

PHYSICS.

	Fresh.-Soph.	Soph.-Jun.	Jun.-Senior
All Students	−5.6	+6.7	+ 8.7
Toledo 1	−3.4	−4.0	+15.9
Chicago 2	+7.7	+0.1	+ 6.7

CHEMISTRY.

	Fresh.-Soph.	Soph.-Jun.	Jun.-Senior
All Students	+0.9	+6.6	+13.3
Toledo 1	+3.0	+1.0	+15.4
Chicago 2	−1.0	+6.7	+18.7

These returns may be interpreted to mean that the biology instruction in Toledo school 1 is more efficient than for the average of the eight of the eight schools; it is less efficient in Chicago School 2. The physics instruction is similarly above average in Toledo School 1 and below average in Chicago School

2. While the chemistry instruction is above average in both these schools, better in Chicago School 2 than Toledo School 1. Apparently we must conclude also that the sciences of the junior and senior years, chemistry and physics, are taught with reference to the applications of their principles to physiology and physical geography more efficiently in Toledo School 1 than in Chicago School 2. The validity of these tentative conclusions can only be determined by further studies in the correlation existing between the grades achieved by students on the questions in the several subjects of these tests and other standardized tests in the same subjects and the grades given by teachers.

These tests were given to pupils in the science classes only, general science in the freshman year, biology (or botany and zoology) in the sophomore year, physics in the junior year, chemistry in the senior year. They were given at the end of the first semester. Only a small proportion of the students in the science classes of the later years had had the sciences of the earlier years, except the general science.

SUMMARY.

The high school instruction in the several sciences is sufficiently effective to produce a marked increase in the ability of pupils to answer questions involving an understanding of important principles.

The high school students apparently do not pick up much knowledge of these science subjects by their out-of-school contacts.

Possibly these tests may be used to determine the relative efficiency of instruction in the several sciences in individual schools when comparison is made with the average of a number of schools.

If the questions of these tests are a fair sampling of the sorts of things the high school science instruction should prepare students to understand, the results of such instruction are rather disappointing, for the grades made are on the whole low.

EDUCATION NEEDS COOPERATION.

The spectacle of superintendents quarreling and wrangling with teachers, of teachers complaining and whining about superintendents, of one educational group attacking and undermining another, is not edifying. We need differences of opinion, we need valiant crusaders for reform, and embattled defenders of present practices, for out of their struggles will truth arise; but above all we need in education a new cooperation of all educational forces that will assume a moral and intellectual leadership for the good of the child and through his development the improvement of the social order.—*The Wisconsin Journal of Education.*

SOME AIMS IN TEACHING ELEMENTARY CHEMISTRY.

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The material for this discussion has been assembled largely with reference to the course in chemistry of the secondary school. The excuse for this lies in the fact that there have been prepared a number of statements of aims in the teaching of high school chemistry and that there are ready at hand a number of the recent text books and laboratory manuals designed for use in presenting such a course.

At the outset it may be well to state that no attempt will be made to blame the high school for any real or fancied lack of preparation of youngsters as they continue their chemistry work in college. On examining figures in two recent studies of high school chemistry in Michigan it appears that only about 2.5% of the high school pupils in Michigan take a continuation chemistry course in the University. Assuming that twice as many may take chemistry in other colleges the figures would still show that only 7.5% continue work in chemistry. This is hardly sufficient to warrant setting up training for college chemistry as a major aim in the secondary school.

If, then, only a small fraction of the high school youngsters continue chemistry in college, what right has a college teacher to suggest what the high school should do in the chemistry course? Aside from the obvious right that an American citizen has to free speech, there are two points to which attention may be called. First, the college freshman is practically an average high school graduate, so there is no marked difference in general ability between the youngster to whom the high school teacher addresses his work in the latter part of the high school and the one whom the college teacher meets in the introductory courses. Second, in college as in high school there are many who elect chemistry as part of a general or pre-professional course with no direct thought of specializing in the subject. As a consequence, the purpose of the earlier college chemistry course is not far different from that of the high school, and the actual differences in content are related to the time allowed for the course, the maturity of the pupil and the equipment available in the two types of school.

Undoubtedly the most significant statement of the aims of chemistry is found in the bulletin of the Bureau of Education

comprising the report on the Reorganization of Science in the Secondary Schools as worked out by a commission of the National Educational Association. In this report the attempt is made, in part, to state the general and the specific values of science study and of some of the individual sciences.

Science instruction is especially valuable in the realization of six of the seven main objectives of secondary education (as defined by another commission of the N. E. A.), namely: health, worthy home membership, vocation, citizenship, the worthy use of leisure, and ethical character. Five specific values of science study are listed and discussed briefly,—(1) the development of interests, habits, and abilities, (2) teaching useful methods of solving problems, (3) stimulation, (4) information values, and (5) cultural and aesthetic values. For chemistry in particular five principal aims are outlined: (1) to give an understanding of the significance and importance of chemistry in our national life, (2) to develop those specific interests, habits, and abilities to which all science study should contribute, (3) to build upon the earlier science courses and knit together previous sciences by supplying knowledge fundamental to all science, (4) to give information of definite service to home and daily life, and (5) to help pupils to discover whether they have aptitudes for further work in pure or applied science.

This exposition of educational aims in chemistry with its further suggestions for the reorganization of the secondary courses has been reflected in all the more recent formulations. In many cases it has been copied quite directly, either in whole or in part. But, while there is much of value in this report there is still a wide gap to bridge in attempting to carry these aims over into the actual teaching of the subject.

In glancing through recent text books and in watching the work done in some of the schools it appears that two of the aims in chemistry just mentioned have been especially prominent as factors in the modification of courses. One is that of giving an understanding of the significance and importance of chemistry in our national life, the other is that of giving information of definite service to home and daily life. In the report itself this latter aim is recognized as being the chief factor in reorganizing high school courses. It is interesting to note that both of these aims are essentially objective and that they lend themselves particularly well to the sorting out of material that has an obvious relation to the criterion by which it has been selected.

Mention of the relation of iodine deficiency to goitre, the use of iodized salt, and the treating of drinking water with iodine would certainly be regarded as an excellent way of illustrating the service of chemistry to medicine. Again, the use of alloy steels to produce stronger and lighter parts for the automobile is an illustration that might well do triple duty in showing the service of chemistry to industry, to home life, and to the welfare of the nation. That is to say, in these cases there is an apparently obvious connection.

There is a wealth of material of this sort ready at hand from which a book of several hundred pages might easily be assembled. The doctor's thesis of F. W. Lyons at the University of Pennsylvania in 1925 dealing with the contributions of chemistry to conduct control for boys and girls of the high school age supplies an interesting outline for anyone who wishes to consider that sort of an undertaking. And the latter half of the text book by the Chicago group contains much material that the chemistry teacher will be glad to have in so convenient a form.

But it is necessary to recall that information of this sort involves chemistry to just about the same extent as the fact that the potato is an important article of diet involves botany. Nor does the naming of elements present teach chemistry any more than citizenship is taught by naming the mayor of a city. There is still the problem of how to teach chemistry with the aid of this material. Granting that this type of content gives a very practical appearance to the subject it must be confessed that the introductory book is inclined to stop right there. One searches in vain for a presentation of the chemistry involved in the things discussed. It looks suspiciously as if the subject leads away from chemistry to medicine, to agriculture, to industry, and a hodge-podge of miscellaneous information about other fields. Curiously enough, if one becomes sufficiently intrigued to try and pursue one of these cases further one becomes aware almost immediately that from the chemical point of view the situation is enormously complex. And then it becomes evident that this is an illustration not of the service of chemistry to medicine or industry, but rather of the other field to chemistry, the service in question being that of presenting chemistry with a problem to study. And in many cases only a tentative start has been made on this study.

In reading the discussion of these aims again it appears as if something fundamental has been lost sight of, unless, indeed, it

has been assumed to be so obvious that it did not need mentioning. To the chemist, trained only incidentally in educational theory, there is much to commend the suggestion of Pope that "the proper study of mankind is man." To the chemist it would appear that the proper study of the chemistry student is chemistry. This may be so obvious that it is implied in all the discussion referred to, and yet there seems to be a distorted vision of chemistry looking out of the aims described. One cannot but feel the implication that chemistry is an objective, concrete, material thing that can be set on the table, to be inspected and measured or compared and contrasted with other objects there present. That chemistry can be dissected out of modern life and set along medicine, for instance, and their shapes and volumes recorded, and their influence on each other measured by the application of some sort of gravitational principle. But you and I know that that is a false picture of the situation; that, so far from being able to study chemistry as an objective unity, the technique is developed in only a very imperfect way for even staining the tissues of modern life and recognizing the veins of industry as distinct from the arteries of chemistry. There is no sharp line where one leaves off and the other begins.

The underlying aim of an elementary course in chemistry, therefore, is to give a reasonably accurate picture of what chemistry is. The picture will necessarily be an outline, with only a hint of detail to convey correct impressions. It is impossible in a year's course to give more than a very sketchy notion as to what chemistry is. As a matter of fact a four year course in chemistry has only filled in the picture a bit and should still leave the student with a realization of the meagreness of his information about chemistry. Occasionally the college senior thinks he knows quite a little chemistry, but the first practical problem he meets will probably go far toward relieving the pressure of the hat band.

Assuming, then, that the aim is as just stated, it is only fair to attempt to show what chemistry is and to offer suggestions that might help in selecting from the abundance of material a reasonable content for a year's course. It need hardly be hinted, however, that nothing more than a bare outline for the development of such topics can be presented at this time.

First, then, chemistry is a body of facts. These facts are bits of information accumulated through many years and by many people; occasionally under the urge of simple curiosity,

occasionally with an interest in systematic study, but in the vast majority of cases with hardly a realization that a chemical observation was being made. A practical need was to be served, and various things at hand were tried until some combination worked. Sometimes this was of sufficient importance to be held as a trade secret, but so long as it worked there was little concern with why or with how it might be improved. Thus the art of chemistry has been developing, and the science of chemistry is finding a hard time trying to catch up.

In using the term "facts of chemistry," there is some danger of misunderstanding. To avoid this the phrase may be defined as follows: the facts of chemistry are observations of changes taking place as different kinds of matter react on each other. In a group of this sort it is not necessary to indicate the various conditions under which the kinds of matter may be brought together or the variety of ways in which observation may be made that anything has happened.

But to emphasize the meaning of the term, fact, an illustration may be used. Suppose the question were asked: "Is it a fact that sodium hydroxide reacts with hydrochloric acid forming water and sodium chloride?" If the experiment were tried of mixing two such solutions, so far as just visual observation is concerned nothing would happen. But it is very simple to add to the acid a bit of litmus solution so that a red color appears, and then as sodium hydroxide is added a change of color takes place and the solution finally becomes blue. Or the solutions might be tested with a thermometer. The temperature is noted, then the two are mixed and the temperature again taken. From this observation also it would appear that something has happened. Or the properties of a hydrochloric acid solution may be tested in a variety of ways,—by taste, by action on iron or marble, by reaction with silver nitrate, etc.—and then, after after adding the sodium hydroxide these tests may be repeated. The sour taste has disappeared, being replaced by a salty or bitter taste according to the care with which the solution is neutralized. The iron and marble no longer dissolve, nor is gas formed at their surfaces. With silver nitrate, however, the same curdy white solid forms in the solution. Evidently, then, many of the properties of a hydrochloric acid solution disappear when sodium hydroxide is added. In the same way many of the properties of the sodium hydroxide solution disappear when this is treated with hydrochloric acid.

Even this much of an exposition of the case gives only a bare hint of the amount of experimental information that may be brought to bear on the question. But, in its light let the question be repeated: Is it a fact that sodium hydroxide reacts with hydrochloric acid forming water and sodium chloride? In the sense in which the word fact is properly used the only correct answer to the question is, No. Facts of chemistry are observations of things happening as kinds of matter react. As such they are impersonal, capable of independent witnessing by trained or untrained workers. They are physical changes that may be detected and measured by physical means.

But, you ask, isn't it true that these two substances do react in the way indicated? And the answer from the chemical point of view is Yes. The explanation of this answer leads to the second general statement concerning chemistry.

Chemistry is a body of inferences, postulates, and correlations. One does not directly observe that a particular reagent is a solution of hydrochloric acid, unless one believes the word of the label or of someone who tells him so. But a solution may be obtained that the chemists have agreed to call hydrochloric acid, and, by carrying out a series of observations of similarity of properties between this and the reagent in question, one may infer finally that the name hydrochloric acid belongs to one as much as to the other. Or, if the known substance hydrochloric acid is not available, but an adequate chemistry book is at hand, the properties of hydrochloric acid as listed by other workers may be compared with those of the given material and judgment rendered.

The postulates of chemistry are the chemical substances that have been set up and recognized as involved in the chemical explanation of the reactions taking place. These are the atoms, the molecules, the molecular aggregates, and, more recently, the electrons and the protons. And the correlations of chemistry are the laws, the principles, the generalizations by which the attempt is made to lay trails through the labyrinth so one may find his way about in the maze. Perhaps these last statements need amplification to make their meanings clear, but due to the limited space available they will be left as they stand, hoping, nevertheless, that they have conveyed fairly accurate impressions.

When the statement is analyzed, therefore, concerning the action of hydrochloric acid and sodium hydroxide, it is found

to be much more than a mere fact. It embodies inferences made from many facts, it involves several postulates, and the chemist who says it is true may be applying some of the generalizations of chemistry in arriving at his own decision in the case.

If, then, an apparently simple case is as complex as this,—and no attempt has been made to show the full complexity of what is fairly common knowledge,—one need not be surprised at the small amount of chemistry that is learned in a year. One might be inclined rather to ask the question whether there is any chance of teaching enough chemistry in a year to warrant taking this much time off from something else that is being handled in the same meagre fashion. Before touching on this question at all the third statement as to what chemistry is should be presented.

Chemistry is a point of view, a method of approach. Whether dealing with the simpler case which sometimes proves to be so complex as one digs into it, or with the more complex case which sometimes turns out to be so simple in the sense that it may be only a less well known illustration of a common sort of chemical situation,—in either case the chemical description of the problem is the same. It involves the attempt to recognize the various types of matter, to determine the conditions under which they are being brought together and to refer the net effect observed to the behavior of chemical individuals under the conditions given.

The particular problem may be the preparation of a substance for testing certain of its properties, it may be the so-called practical problem of cleaning out a clogged drain pipe, or the adequate disposal of wastes when the state no longer permits the company to dump them into the river. Whether the time required to work it out is a few minutes or many months the method of studying the situation is essentially the same in the three cases.

If the question is again asked, what shall be included in the high school course of chemistry the answer is, material that shall give a fair understanding of these three aspects of chemistry,—chemistry as a body of fact, as a set of inferences, and as a point of view.

It should include discussion of, and practice in, fact gathering. Metallic copper might be the basis of an exercise of this sort. A number of the characteristics of copper might be observed,—some of them even requiring a moderate amount of study.

Among these might be included the fact that copper does not dissolve in hydrochloric acid, and that it changes in appearance on heating in the air and the appearance is not restored as it cools. This new material may be examined in some of the ways the copper was examined. The properties are different. Evidently it is not copper. It dissolves in hydrochloric acid while copper doesn't. If such a solution be prepared and treated with metallic zinc a curious thing takes place. The blue color disappears and a copper colored powder separates from the solution. If this powder is filtered out and the excess zinc removed, it may be tested in various ways that will make it clear that this substance is metallic copper. This is interesting. There was copper to start with. On heating it in the air the copper as such disappeared. However, by treating the product in a certain way that caused it to disappear and then using a little more of chemical magic the copper appeared again. Was the copper there all the time?

In the sense that the copper could be identified by the properties of metallic copper it was *not* present. It actually disappeared. But in the sense that a product was formed out of which the copper could be obtained the copper *was* present. This leads to the conception of an element as distinct from an elementary substance. The element copper was present all the time, first in the metallic copper, then in the copper oxide, then in the copper chloride solution, and again in the powdered metallic copper. This is the simplest assumption to make in accounting for the facts observed.

This same set of reactions might be used, by the way, in showing something of the quantitative aspect of chemical changes. If the copper were weighed, then heated in air and the product cooled and weighed a fairly definite increase in weight might be noted. Then the rest of the operations might be carried out,—dissolving in hydrochloric acid, reducing with zinc, removing the excess of zinc, washing, drying, and weighing the powder. If these were carefully done it should be possible to recover essentially the same amount of metallic copper as was started with. And in this way an appreciation of the experimental basis of the law of conservation of matter might be taught.

It is clear that the material suggested here would form the basis of several laboratory periods of work. It is also clear that it would be impossible to cover more than a very limited number of such studies of typical chemical material in the course of a

year. It is important, therefore, that this material be so selected as to be representative of the field of chemistry. It should be taken up slowly enough to be intelligible, and fully enough to get down to the fundamentals of the subject. It should not merely keep the students busy, nor should it merely give them a mass of isolated bits of information.

It is obvious that a year's work cannot cover the subject in much detail. The high school text book runs from three hundred to five hundred pages long. The Handbook of Inorganic Chemistry by Gmelin-Kraut comprises a number of large volumes occupying altogether some three feet of space on the library shelf, and this consists largely of bare statements with references to the literature for more complete discussion. Volume I of Mellor's Comprehensive Treatise on Inorganic and Theoretical Chemistry is over 1,000 pages long and covers only hydrogen and oxygen. Hofman wrote a book 556 pages long on the Metallurgy of Copper. Morley used over 100 pages to describe his work on the densities of hydrogen and oxygen and the ratios by volume and by weight with which they combine. Incidentally, Morley spent some fifteen years on this work, taking several months just learning how to weigh the glass flasks with reasonable accuracy. Landolt worked during seventeen years on the problem of experimentally testing the law of conservation of mass, which the text book states in two or three lines for the pupil to commit to memory and repeat on request.

It is difficult to tell just when to stop when one starts on a topic as comprehensive as the one under discussion. But probably the discussion should not be concluded without mentioning two additional points.

First, the course should provide the pupil opportunity to practice chemistry and he should be tested for his ability to do this. With the mass of material crowded into the present course there is nothing for the pupil to do but to carry out the laboratory work in a routine fashion and commit a fair portion of the text book to memory. It is useless to complain that the student doesn't think. He doesn't have time to. The teacher or the book does his reasoning for him and he is only expected to go through it again parrot fashion, even being marked off at times when he uses his own words.

To test a pupil's ability to think chemically it is necessary to present him with adequate facts and then confront him with a

new chemical situation and ask him to work his way out. This takes time. Several partial periods of class work were spent recently in a second year college course trying to develop a useful appreciation of the relation of dichromates to chromates. In all at least two hours' time was devoted to this and the students were many of them only beginning to see what it was all about. Part of the difficulty may have been faulty training, part of it may be that this was the first time they had really been asked to think in that way. Evidently the exercises set must be restricted in character and must be capable of satisfactory solution by the pupils. A more advanced test of this same type would be one requiring the pupils to assemble their own facts. This, of course, presents the characteristics of a research problem, but in its simpler form it should be present in every course in chemistry, increasing in complexity in the more advanced courses.

The last point to be made is this: the conventional course in chemistry fails to accomplish its purpose largely because there is no connecting thread running through it. Much could be done to improve it by organizing the course around some central theme. Faraday showed how a considerable amount of chemistry might be tied together in his very interesting series of lectures entitled, "The Chemical History of a Candle." It would be possible to take any one of a number of common substances and build the whole of an elementary course about that material and its chemical relations. There is no time to develop this idea, but it would be perfectly feasible to develop a course about the one substance, salt.

This is a substance of every day acquaintance. It is used directly in enormous quantities as a seasoning and as a preservative. From it many important substances are made. The Solvay process uses it to make, among other things, sodium bicarbonate, which is used by the thousands of tons in medicine and in smaller quantities as an essential constituent of baking powder. By electrolysis sodium hydroxide, hydrogen, chlorine, and many other products are obtained, all of them important chemically, industrially, in the home and in the life of the nation. Such a course could be given a content as rich as anyone might desire. And with it all the only limitation as to the amount of chemistry that could be taught in it would be the time, the preparation of the teacher, and the equipment available.

The real aim, therefore, of the course in chemistry is to teach chemistry.

AN IMPROVEMENT TO THE EARTH INDUCTOR.

By A. L. Fitch,

University of Maine, Orono, Me.

The earth inductor as used in most laboratories consists of a coil of copper wire of about one thousand turns wound on a wooden form about twenty centimeters in diameter. The coil is usually wound in a groove with rectangular cross section. The coil is then arranged on a wooden frame so that its axis may be set in any direction desired and is furnished with a spring and trigger so that it will rotate through 180° upon releasing the trigger.

To determine the horizontal component of the intensity of the earth's field, the coil is set normal to the plane through the meridian, the ends of the coil are connected to a ballistic galvanometer and the coil is rotated by the spring through 180°. The turning of the coil in the earth's field produces an electromotive force in the coil. This electromotive force in turn produces a current in the coil which passes through the galvanometer. If the coil turns very quickly the current through the galvanometer integrated over the time of throw will give a ballistic throw of the galvanometer which is proportional to the quantity of electricity passing. This ballistic throw is however dependent upon the resistance of the circuit so that the galvanometer can not be calibrated with a battery and condenser but must be calibrated in a circuit with a resistance the same as it is to be used in. This is usually done with a standard mutual inductance and battery. The beginning student is not able therefore to perform the experiment intelligently and with advanced students the experiment is unnecessarily complicated.

In this laboratory we have added a second coil of wire over the one on the instrument when purchased. This coil has twenty-seven turns. The modification enables us to eliminate the complicated calibration of the galvanometer, cited above. The experiment is performed as outlined above to get the throw of the galvanometer when the coil rotates in the earth's field. The coil is then held rigidly and the second coil is connected through a variable resistance and ammeter to a battery. When the circuit is closed the galvanometer will show a throw due to the change of flux in the coil connected to it. This swing of the galvanometer may be adjusted by altering the resistance

until the swing of the galvanometer is the same as with the coil rotating in the earth's field, or a curve may be plotted connecting the current through the coil and the resulting galvanometer deflection. From this curve the current may be read that will give any swing of the galvanometer between the limits plotted.

The flux change due to the coil rotating in the earth's field is given by

$$\varnothing = 2AH.$$

where A is the average area of the thousand turns and H is the horizontal component of the intensity of the earth's field. The time rate of change of this flux is the electromotive force produced in each turn. The total electromotive force produced is therefore

$$V = n\frac{d\varnothing}{dt}.$$

The current flowing is the quotient of this electromotive force and the combined resistance of the coil and galvanometer. So that

$$I = \frac{n}{R}\frac{d\varnothing}{dt}$$

and

$$Q = \int_0^t I\,dt = \int_0^{\varnothing} \frac{n}{R}\,d\varnothing = \frac{n}{R}\varnothing = \frac{n}{R}2AH$$

But when the current flows in the added coil the current in the first coil is given by

$$I = \frac{M}{R}\frac{di}{dt}$$

or

$$Q = \int_0^t I\,dt = \int_0^I \frac{M}{R}\,di = \frac{M}{R}I$$

where M is the mutual inductance between the two coils. If this quantity of electricity is the same as obtained by turning the coil in the earth's field, as evidenced by the same throw of the galvanometer,

$$\frac{n}{R} 2AH = \frac{M}{R} I$$

and

$$H = \frac{MI}{2An}$$

The mutual inductance of the two coils, the average area of the coil and its number of turns being known as constants of the instrument, the only quantity necessary from experiment is the current which will produce the same ballistic throw of the galvanometer as the turning of the coil in the earth's field.

The mutual inductance of our coils was 0.0098 henry, the average area was 387 cm², the number of turns was one thousand. Data was taken for the throw of the galvanometer against the current in the added coil when the current was suddenly caused to flow. These data are plotted in Fig. 1. Data

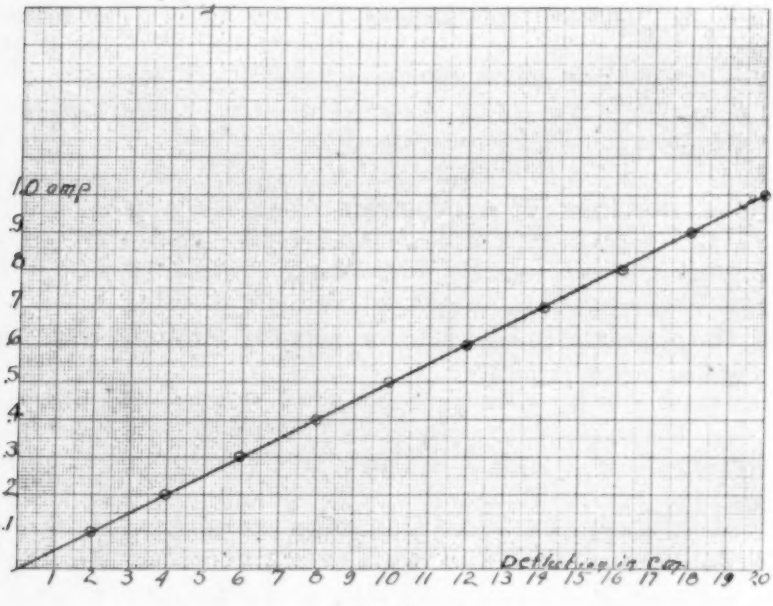

FIG. 1.

was then taken with the coil rotating through 180° set with the axis vertical, the initial and final planes of the coil being normal to the plane of the meridian, and with the axis

horizontal. These data are shown below.

COIL AXIS VERTICAL.	
Deflection of galvanometer	2.6 cm
	2.58
	2.6
COIL AXIS HORIZONTAL.	
Deflection of galvanometer	8.6
	8.6
	8.6

If the current is read from Fig. 1 which caused these throws of the galvanometer and substituted in the formula for the field we get 0.162 gauss for the horizontal component of the earth's field and 0.544 gauss for the vertical component. These values give an angle of dip of 73°20′. Maps issued by the U. S. Coast and Geodetic Survey give the horizontal component here as 0.157 gauss and the dip as 74°40′. It must be remembered however that our data were taken in our laboratory where the field may be quite different from what it is in the open.

It would seem from this discussion that makers of earth inductors should add a coil as we have done and state the mutual inductance of the coils as one of the constants of the instrument.

It would not detract in any way from the present uses of the instrument and would aid materially in the computation for the earth's field in all laboratories. Those who have instruments without the second coil may add one very easily. If means are not available for measuring the mutual inductance of the coils, it may be computed from formulae.

I wish to thank Dr. C. B. Crofutt for supervising the work of Mr. H. W. Saunders, who obtained the data given above.

PENSIONS INVOLVE NO EXPENSE TO NASHVILLE TEACHERS.

Contributions to the pension fund are not required from public-school teachers of Nashville, Tenn. Taxation not exceeding one-tenth of one mill of assessed valuation provides the moneys required.

Pensions correspond with the pay of beginning teachers, the idea being that the beginning teacher receives the minimum for living requirements. The pay of the pensioner varies from time to time, therefore, with the changes in the pay of beginning teachers. This unique provision will prevent the distressing conditions that came to pass during the inflated period when set pensions did not provide a living.

The salary scale adopted in October, 1927, provides $1,200 a year for beginning teachers, although 20 "cadets," teachers in training, receive $720 a year each. No pension may exceed one-half the salary of the teacher at the time of his retirement, however, and it happens that the smallest pension paid is $600 a year. Seventeen teachers are now on the retired list.—*H. C. Weber, superintendent of schools, Nashville, Tenn.; in School Life.*

OUR CALENDAR.

By C. N. Mills,
Normal University, Normal, Ill.

What do we mean by "Calendar"? To many persons it means a program of procedure during a period of time. To the church and business world it means the arrangement of the days of the year according to months and weeks. The word "Calendar" is of Latin origin meaning the name for the first day of each month.

One of the earliest purposes of the study of the motions of the sun, moon, and stars, was to find a convenient measurement of time. The first unit of measure was the day and night, since the alternation occurred regularly and thus furnished in all ages a most definite unit of time. This unit of time might have been used for chronological purposes had it not led to such large numbers as the centuries elapsed. Today we find the count of time by days generally used for periods not greater than the month.

The next unit of time was based on the motion of the moon. The religious ceremonies of the Jews were arranged at the time of the new moon, which occurrence brought out the idea of the month. As the moon does not make an integral number of revolutions around the earth in a year, it was necessary to add, at intervals, an extra month in order to keep the year in harmony with the seasons. Even today the Romans and the Greeks cling to the use of the month in determining certain festivals.

Also in early antiquity the week was used as a division of time. The names of the seven celestial planets gave a basis for the names of the days of the week in use today. The days mentioned were the Sun's day; Moon's day; Mars' day; Mercury's day; Jupiter's day; Venus's day; and Saturn's day. Since the week does not correspond to any astronomical cycle, it is not a good unit of time. Next to the day and the month, the most definite and striking division of time is the year. The year among the ancients meant the time interval measured by the return of the seasons.

The Egyptians, Greeks and the Romans were the first to arrange systematically a calendar for the church and business activities. The Egyptians used 12 months of 30 days each, and five additional days making 365 days for the year, even though they knew the day year was approximately 365¼ days.

The Greek calendar year based upon the lunar month was

improved by the use of the "Meton Cycle." During 19 solar years the moon changes 235 times. If the 235 lunar months are divided into approximately 19 years, the mean length of these years is near enough for purposes of civil calculations. These years are numbered from 1 to 19, thus giving what is known as the "Golden Number." History tells us that the number was placed on monuments in letters of gold.

Easter seems to be the only religious festival in all Christian countries based on the motion of the moon. Briefly stated, Easter is that Sunday following the first full moon (known as the Paschal moon) which occurs on or after March 21 (Vernal Equinox). The Golden Number for any year reveals on what day, or how many days after the Equinox, the Paschal moon occurs. However, this method of determining the time of Easter will lead to errors, and more accurate methods must be employed.

The calendars used in Christian countries have as their basis the plan set up by Julius Caesar. The Julian Calendar, of 45 B. C., independent of the motion of the moon, consisting of 365 days, and every fourth year 366 days (called a leap year), continued unaltered for about sixteen centuries. The Julian year was about 11 minutes and 14 seconds short of the solar year, and for this reason by the sixteenth century the Equinoxes occurred on March 10 instead of March 21.

In 1582 Pope Gregory XIII decreed that October 5 should be October 15. In order to correct the error of the Julian calendar, all century years whose date numbers are exactly divisible by 400 should be leap years, in addition to the years whose date numbers are divisible by 4, excluding the century years. Even this plan will give a slight error which will amount to one day in about 4,000 years. At present we need not worry about this last correction. The Gregorian Calendar, which is only the Julian Calendar amended, is now used in practically all civilized countries (Russia made the change in 1923). At present the Julian Calendar is 13 days behind the Gregorian Calendar.

It is an interesting study to trace the developments leading to the establishing of the coincidence of the calendar and the astronomical year. However, the practical importance of such is not of much concern. We are interested that summer and winter, seedtime and harvest, shall occur at the same time of the year. It is not of the slightest importance that they should occur at the same time 4,000 years ago, or that the Equinox, 4,000 years hence, should occur in December.

Our present calendar is merely a rough tool. A person not versed in the mathematics of the calendar can find, only with ease, the dates within the month or a few months ahead. In business practices it is necessary to determine dates in the future years. Current wall calendars are generally accessible, but it is no easy matter to calculate or determine old or new dates. The following questions will convince anyone of the troubles met. On what day of the week were you born? On what day of the week was the Declaration of Independence signed? On what day of the month will Easter occur in 1928, 1930, 1950? On what day of the week and what day of the month will a 20 year lease expire? What months of the year have five Sundays?

The reform of the Gregorian Calendar was started by the French government in 1792, but nothing permanent came of the movement. During the last twenty-five years much agitation has been set up demanding a decided change. The movement centers around two main questions:

1. Shall the date of Easter be fixed without changing the calendar?

2. If the same days of the year are to fall upon the same days of the week, how is this arrangement to be brought about?

Several plans have been proposed for the reform of the present calendar, and I shall mention only two of the best plans. In 1918, Congressman Smith, of Michigan, introduced a bill which provided for a year of 13 months of 28 days each, the extra month, called Sol, coming between June and July. In 1920, an International Chamber of Commerce was organized in Europe to consider the calendar reform, but no definite plans were adopted. In 1922, Pope Benedict called a meeting of astronomers to discuss proposed reforms. The topic of calendar reform was under discussion at the sessions of the League of Nations in 1922-1923-1924.

One of the best forms of the proposed new calendar has been outlined by Dr. Charles F. Marvin of the U. S. Weather Bureau. His calendar is very simple. Under his plan the year is divided into 13 months of 28 days each. The extra day he proposed to place between Christmas and New Year's day as an additional holiday. For leap years (the number of the year must be divisible by 4, except century years which must be divisible by 400) another holiday should be placed between the two midsummer months. His calendar would appear as below.

Sun.	Mon.	Tues.	Wed.	Thur.	Fri.	Sat.
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28

By this plan the months would have the same dates for the days of the week, and no revision need take place for at least 12,000 years.

It is evident that the commercial and the industrial world will reap the largest benefits from a calendar reform, and for this reason the business world should take the initiative in the movement. Authorities of the Church Orders have agreed that the date of Easter could be arranged as well as other important church festivals.

FROM THE SCRAPBOOK OF A TEACHER OF SCIENCE.

By Duane Roller,
Calif. Institute of Technology, Pasadena.

Education has perhaps had less scientific research upon it in comparison with the number of words uttered about it than any other field of human endeavor with the exception of war and religion.—*Raymond Asa Kent, educator, in the Phi Delta Kappan, August, 1926.*

Genius may be almost defined as the faculty of acquiring poverty.—*Edwin Percy Whipple, American critic and essayist.*

The great secretary of nature—Sir Francis Bacon.—*Izaak Walton seventeenth century English writer, in The Life of Herbert.*

Books must follow sciences, and not sciences books.—*Francis Bacon, philosopher, in Proposition Touching Amendment of Laws.*

If a single cell, under appropriate conditions, becomes a man in the space of a few years, there can surely be no difficulty in understanding how, under appropriate conditions, a cell may, in the course of untold millions of years, give origin to the human race.—*Herbert Spencer, English philosopher, in Principles of Biology.*

Science is the natural ally of religion.—*Theodore Parker, American theologist and scholar.*

Devotion! daughter of astronomy!
An undevout astronomer is mad!

—*Edward Young, eighteenth century English poet, in Night Thoughts.*

THE SYSTEMATIC SOLUTION OF ARITHMETIC PROBLEMS.

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McClymonds High School, Oakland, Calif.

(Concluded from January)

Problem 11. Mr. Smith owns a 1/4 interest in a taxi line and Mr. Jones owns the rest. Mr. Jones receives $980 more a year than does Mr. Smith. How much does each receive?

Step 2. J receives 980 more than S, and
3 times S = J.

Step 3. If S received 980 more he would have as much as J,

$$980+S = J$$
$$\|$$
$$3S$$

also 3S = J, or

We may then write 3S instead of J. 980+S = 3S.

Then the solution was completed by means of algebraic methods.

This problem was also solved by other pupils through the use of another condition not quite so obvious.

The difference between 3/4 and 1/4 is 1/2.

It is also 980.

Therefore 1/2 of the total amount is 980, etc.

Questioning failed to reveal the thought that started this reasoning. The class had not been taught to express the same quantity in two different ways, then to equate the resulting expressions. "Inspiration" then would be a good word to use in describing the mental process.

But how can we teach this process to children?

Problem 12. A man leaves a certain place at 8:00 a. m. and travels due east at the rate of 20 miles per hour. One hour later another man follows in the same direction at the rate of 30 miles an hour. What time will it be when the second man catches the first?

Attacking this problem by conventional methods soon leads the child to a blind alley. He bravely starts with:

Given: First man starts at 8:00 a. m.
Second man starts one hour later
Rate of first is 20 miles an hour
Rate of second is 30 miles an hour.

To be found: The time of the day when they meet.

Processes you will use:

This disintegrating analysis removes every quantity from its setting, from the place where its more or less obvious relationship to other quantities is indicated. When the problem is read as a whole the solver perceives more or less definitely the essential relationship: that the men travel the same distance. Without this idea the above tabulation of numbers is worse than useless.

It should be noted that we have here two different problems. One asks how long it will take the second man to overtake the first. After this is solved the second problem, which asks for the time of the day, becomes possible of solution. But the above tabulation seems to suggest that both can be solved at the same time!

Solution 1. The first man has a lead of 20 miles. The second man reduces this lead at the rate of 10 miles an hour. In two hours he will catch the first man, etc.

The solver obviously restated the problem mentally somewhat as follows, leaving out the "time of the day" part of the question: A travels 10 miles an hour faster than B. B has a 20 miles lead. That is, A is reducing this lead by 10 miles every hour. How soon will A overtake B?

It should be noted however that the restatement cannot take place until a part of the solution is completed mentally. That is, when a part of the solution is performed mentally it is not difficult to solve problems really involving complex settings by means of a few simple operations. Most "shortcut" solutions are of this type, the shortcutting being simply the omission of the preliminary verbal analysis and combination of numbers in the verbal or written presentation. The skilful computer reads the problem and writes down the simple arithmetic operation required to obtain the answer. He then claims that the problem is simple.

The above given solution plays havoc with carefully compiled problems of the "overtaking" type, so frequently used by algebra text writers. Pupils who have learned the trick fail to see why they should use long and complicated algebraic processes to solve problems that can be solved mentally by arithmetic methods.

Solution 2. Step 2. The distances that they travel are equal.

The fast man travels one hour less than the slow man.

Distance = rate$\times$time

(The time equation obtained from the second condition is:)

1 hour+hours of fast = hours of slow. (1)

Hours of fast = Dist. ÷ Rate = Dist. ÷ 30
Hours of slow = Dist. ÷ 20 (Substituting:)
(From 1:) 1 + Dist. ÷ 30 = Dist. ÷ 20
(Omitting the obvious reduction:) 1 = Dist. ÷ 60, Dist. = 60 miles. Then the time was found. The determination of the time of the day when one overtook the other constitutes, as noted above, a separate problem.

The relation diagram shows that this is one of the two possible systematic solutions, when the formula D = RT is used.

$$\begin{array}{ccc} D & = & d \\ \| & & \| \\ 30 & & 20 \\ \times & & \times \\ 1+T & = & t \end{array} \qquad (1)$$

The other solution being: D = d

$30T = 20t$, whence $T = 2t/3$

then substituting in (1) and solving the resulting simple equation.

If the formula D = RT is reversed to T = RD we obtain another set of two solutions. The formula would be read somewhat as follows:

Total time in minutes = The number of minutes required to travel a unit of distance × number of units of distance. We then have as above

$$\begin{array}{ccc} 60+T & = & t \\ \| & & \| \\ 2 & & 3 \\ \times & & \times \\ D & = & d \end{array}$$

Substituting by means of the vertical equations into the time equation,

$60 + 2D = 3d$. But $D = d$, whence D = 60 miles.

The arithmetic reasoning given by a boy who used this procedure mentally was somewhat as follows: The fast man makes a mile in 2 minutes and the slow man a mile in 3 minutes. The fast man gains a minute in every mile. Therefore it will take him 60 miles to overtake the slow man or 2 hours, etc.

Discussion.

The solutions outlined do not show much "reasoning" of the conventional type. They show the exact points where reasoning begins, the central ideas or bases of reasoning. The solutions

are not brilliant, no "sinces," "buts," or "therefores" seem required; no ingenuity is displayed, just plain perception and stolid grinding of the answers. The pupils have been trained to recognize and state concisely the essential quantitative thoughts in problems and to reject the irrelevant features. That is, they were taught to *abstract* the quantitative features. But, instead of using letters and algebraic symbols from the first, they used words. These verbal equations automatically divided the problem statement into small parts, one for each term. These parts were then examined separately and put into shape suitable for substitution in the verbal equation without fear of losing sight of the places where they fitted. The pupils made plans first, worked on details, then integrated the latter.

The procedure shown is exactly the reverse of the conventional procedure which begins by making a list of what is given and of what is to be found, preparing the material for mental substitution in an equation which has not yet been written or stated, and which as a matter of fact is not usually stated explicitly, the exception happening when a "since" statement is made. The pupil is then required to state what he is going to do with this material, meaning what arithmetic processes he is going to use. This he is expected to do without any assistance from any symbol, while reading the bulky statement of a problem containing irrelevant details. (See problem 8.) Then we wonder why teaching children to solve verbal problems is the most difficult part of the work!

Another defect of the traditional procedure is revealed when children solving problems are watched. Almost invariably they stop to multiply or divide certain numbers. Whenever this is done the chain of thought is broken for a few minutes. They have then to go back to the whole problem, form their plan again, then look for some other suggestion. Sometimes a problem is possible of solution in two or more different ways and the second reading suggests the possibility of a different sequence of processes or a different combination of the numbers *already used*. This leads to bewilderment and to discouragement. The described method, on the other hand, automatically suggests the next operation in a definite way. One plan is present and it remains in plain sight.

Another argument in favor of the described method is that it prepares for future equation work, a procedure approved by the

National Committee on Mathematical Requirements. The transition from arithmetic to algebra is made easier. Abstraction from a problem statement to an algebraic equation constitutes too abrupt a jump for immature minds not accustomed to sustained mental effort. The described method, on the other hand is a process of

1. Abstraction to short quantitative statements,
2. Abstraction from the latter to symbols, and,
3. Abstraction from symbols to numbers.

Also algebraic symbols such as + or − automatically suggest the necessary operation. Asking the child to state the operations that he is going to use assumes that he has a complete plan in his head all ready to be carried out.

The three abstracting steps are well illustrated in problem 1.

1. *Had* less *what is spent* gives *what is left*
2. *Had*−*Spent* = *left*
3. 200−143 = left.

Persons who have solved problems for a number of years have gradually trained themselves or learned in some way to shortcut these successive abstractions, to perform the first two mentally, often without consciousness of the process. They read the problem, state the essential points verbally or mentally, substitute verbally or mentally, then triumphantly put down the *simple* arithmetic operation required to complete the work. Thus they would solve the above problem by writing

$$\begin{array}{r} 200 \\ -143 \\ \hline 57, \text{ ans.} \end{array}$$

The writer would like to suggest that a still more efficient way is possible. Read the problem, make your plan mentally, perform all operations mentally, and just put down the final result. He can solve most textbook problems mentally himself, and until some efficiency expert invents some way of solving two or more problems at one and the same time, the writer's method is 100% efficient.

But little children must learn to walk before they can be profitably taught to run, and we do not try to teach them the most efficient way when they take their first steps. The purpose of education is to *educe*, to develop power to solve problems and not to provide practice in high-speed guessing, more or less haphazard and practically undirected. 62% proficiency in solving

problems is an easily lost proficiency, once school days are past. But the ability to find and state concisely essential thoughts and to follow a definite procedure is one that increases with every problem solved systematically. This ability is also of the kind that is transferred to other fields.

Conservatives will probably raise the well known objections. "All this may be true, but this method is too slow, too cumbersome, too difficult. The business man will not tolerate this kind of work. It is not psychologically, pedagogically, scientifically, or logically correct. It should be researched by scientific methods before it is offered to the common or garden variety of teachers. If it were any good it would have been recommended long ago by authorities. Teachers cannot teach it, pupils cannot learn it, textbooks do not present it. Even if it were correct, if pupils could learn it and teachers could teach it, it is not preferable to the present methods. The trouble is not with present methods, it lies in the low mentalities of most school children, and in the fact that most teachers have not taken enough courses at our universities."

But we know that "present methods," according to many writers, simply do not exist. Thus Thorndike, in *The Psychology of Algebra*, page 438, makes an interesting statement: "Mathematic reasoning is successful guessing. To the psychologist it appears that the procedure of able pupils is largely guessing or making an hypothesis until you guess right . . . ." The unsuccessful pupil then is merely one who is unfortunate in his guessing, one who has not had time to verify his hypothesis or to modify his guess. We can see now why some authorities consider that problem solving ability depends upon symbol manipulative skill. The pupil who can make 100 guesses in 15 minutes, verify 80% of them, and obtain 8 correct answers, will always win a higher score when solving 12 problems than the plodder who can make only 20 guesses, verify them all, and secure 7 correct answers. But the plodder can console himself by the thought that his score will always be better than that of the systematic thinker who does not guess at all, but analyzes and understands thoroughly only four or five problems in the same time. But the systematic thinker, if allowed to seek higher education, and if permitted to enter college, is usually found to solve a satisfactory number of problems a few years later. In problem solving as in other human activities "form" is more important than mere speed in the early stages.

Another quotation would not be amiss. The November and December issues of *The Elementary School Journal* contains an article describing an extensive experiment on problem solving ability. The contributors came to the conclusion that pupils taught to solve by means of "analysis" or by "analogy" methods did not improve in problem solving ability any faster than pupils who were allowed to solve "by any method that they may choose." It did not seem to occur to the contributors that what they called methods were so only in name.

To a person who has not become proficient in a new method the latter always appears more cumbersome than a better known procedure regardless of the inefficiency of the latter. Thus the writer's pupils, when beginning the study of the metric system, often remark that the latter is slower, more cumbersome, and more complicated than the English system, an opinion shared by the majority of English speaking people. But this belief does not change the actual relative difficulty between the two systems.

To an experienced computer solving an easy problem the act of writing down a plan is certainly more cumbersome than carrying the plan in his head. But the question is not of cumbersomeness to trained adults. It is: What is to be done when children have not any plan to carry in their heads, have never been shown how to plan, and do not know that it is possible to form a plan?

Furthermore experience has shown that slowness while learning a process, while obtaining a result for the first time, is not a criterion when judging of the merits of a method. Thus learning to type by the touch method is infinitely more cumbersome than learning by the lettered keys method. The results are also far slower in appearing. But the ultimate results are far more satisfactory. In mathematics we should aim at mastery over processes of quantitative thinking, and not at habituated mastery over symbol juggling.

But the first step toward mastery is complete comprehension. And the latter can be attained only provided the teacher furnishes complete and satisfying explanation of the troublesome details.

If a child is unable to make the brief quantitative statements illustrated in this lecture he is unable to form a clear plan. This may be due to various causes such as vocabulary difficulties, lack of mentality, lack of habits of study, and other causes be-

yond the scope of this paper. The vocabulary difficulties may be avoided to a large extent if children are required to read the problems assigned for home work at the time of the assignment. Strange words and unfamiliar phrases are easily disposed of in this fashion. Low mentality, at least as measured by present methods, is not necessarily a hindrance, as the writer taught problem solving to pupils who tested as low as 80 I. Q. Such pupils are found to be very slow in their problem work, but sometimes display an astonishing tenacity of purpose. Thus in a recent test a boy testing 125 I. Q. solved 8 problems correctly in 15 minutes and one more in the remaining 27 minutes, the rest of the solutions being incorrect. The 80 I. Q. boy solved 3 problems in the first 15 minutes and two more in the remaining time. At his own request he was allowed to stay an hour after school. He succeeded in solving correctly 13 out of the 14 problems. Three days later he brought in the solution for the last problem, claiming that he had spent six hours before he succeeded in seeing clearly through it. Considering that this problem had been solved correctly by only four out of twenty-six University seniors and graduate students in a test described in recent educational literature, this boy was doing pretty good work.

The teacher wishing to try the method outlined here is advised not to insist on clear cut, all embracing statements of relationship right from the start. The child solving a problem gets an idea and proceeds to jot it down as quickly as possible before it escapes him, using any words or symbols available at the time. To him these words or symbols are meaningful to a greater extent than the inexperienced teacher realizes. It would be very poor pedagogy to insist upon the use of the symbols used by trained adults, even though these symbols are undoubtedly more effective. The teacher's criticism is indicated after the process is grasped as a whole. It would be also poor practice to insist upon the writing down in full of the whole quantitative statement. Thus in the first problem *had* is the child's symbol. To him it means "the number of dollars that the man had when he started on his journey."

In the writer's estimation the present practice that requires the child to use the conventional symbols before the child has experienced the necessity of expressing anything in terms of x and y or even in numbers, is largely responsible for lack of comprehension of the subject as a whole. Refinement, exactness, and clearness of expression, come naturally as the result of extended

practice in mathematics as well as in other subjects. Formerly we taught grammar for years, forcing children to refine sentences from the very beginning. Now we obtain better results by allowing the child to express himself freely for quite a while before we begin the systematic correction of his expressions. We try to get him to think before we teach him to express the thought grammatically. The elementary mathematics teacher should adopt similar methods and concern himself more with *impressions* before worrying too much about *expressions*. By the way where are now the teachers of grammar?

It may be advisable to drill on making quantitative statements before finishing solutions to any extent. This may be done by making pupils read problems and place their verbal equations on the blackboard, the whole class comparing them and selecting the best. Such reading should precede assignment of home work in the early stages of the instruction.

NINTH ANNUAL MEETING OF THE NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS.

At Hotel Statler, Park Square at Arlington St., Boston, Mass., Feb. 24 and 25, 1928.

The general theme of the program is Mathematics in Modern Life. On Friday morning and afternoon business sessions will be held. The first program session is Friday evening at which the key-note address will be given. This talk will give the historical and philosophical background showing the part that mathematics has played in the development of present and past civilizations.

The Saturday morning program will include two major topics: 1. Mathematics in Science and Modern Inventions. 2. Mathematics in Modern Business, including its use in statistics and in research by large corporations.

The Saturday afternoon program has as its main topic The Challenge of Modern Life to Teachers of Mathematics: 1. The New Mathematics as a Part of the New Education: a. Its Nature and Functions. b. Its Methods and Devices. c. Its Challenge and Opportunity. 2. Practical Applications of High School Mathematics. 3. The Presentation of the Third Yearbook.

On Saturday evening there will be a banquet and one speaker, who will be asked to close the program with an inspirational challenge to the teachers of mathematics.

While the list of speakers has not been finally determined, it will include Walter F. Downey, Olive Kee of Boston, Harry C. Barber of New Hampshire, W. S. Schlauck and W. D. Reeve of New York. We hope to include Max Mason, Charles H. Judd, A. T. Slaught of Chicago University, E. B. Wilson, E. V. Huntington, Julian L. Coolidge, Marsten Morse of Harvard University.

All visiting superintendents are cordially invited to attend the sessions of the Council and our banquet Saturday evening.

Tickets for the banquet may be secured at Hotel Statler.

MARIE GUGLE,
President of the Council.

ATOM STRUCTURE AND ELECTRICAL EYES.

By John Mills,

Author of "Within the Atom."

The arrangement of protons and electrons within an atom can never be directly observed but must always be a matter of inference or deduction from experiments. Each kind of atom has its own peculiar arrangement. In all kinds, however, there appears to be at the center of the atom a compact group, containing all the protons and some of the electrons; and farther out from this nucleus, scattered around, are the remaining electrons.

For that reason an atom is sometimes compared to the solar system where the sun is the nucleus and the various planets revolve around it. All the planets are in the same plane as the sun; but in the atom the electrons outside the nuclear center are not confined in their motions to a single plane. For a crude picture, imagine a flock of small birds driving away some marauding bird of prey. Above and below him, in front and behind, they circle and swoop. He is the nucleus and they the planetary electrons.

Beyond this idea as to the separation and the motion of planetary electrons in an atom, the comparison with a flock of birds would soon become misleading; but in one more detail it is a correct picture. Sometimes in such a flock there may be seen a little apart from the rest a single bird which swings into the crowd and then far out again. Such is the behaviour, it is believed, of one electron in the case of an atom like that of sodium or potassium, and the other alkali-earth metals which the chemist calls "monovalent electro-positive elements." As the bird which circles widest from the flock is most easily diverted and finally separated from it, just so the outermost electron of an atom of potassium is quite readily parted from its associates.

This is one reason why potassium and similar metals, for example caesium, are good materials for the construction of electric eyes. If a properly prepared surface of caesium is exposed to light some of its atoms each lose an electron. The substance, in other words, is electrically light-sensitive; electrons can be separted from its atoms by the action of light.

This phenomenon of light and electricity, known therefore as the "photoelectric effect," is one first noticed by Hertz, the

scientist who discovered, that is first produced, radio waves. Its present explanation in terms of electrons is the result of many researches of many scientists, investigating the broad subject of electronic physics. For its study there was devised the so-called photoelectric cell; and that device, enlarged and perfected in Bell Telephone Laboratories, is an essential mechanism for the electrical transmission of pictures and is the electrical eye in systems for television.

The photoelectric cell is a highly-evacuated glass-tube coated on part of its inside wall with a light-sensitive material like potassium, supplied with two lead-in wires, one connecting to the metallic coating and the other to a ring of some photoelectrically inactive metal such as platinum or nickel. To understand its operation imagine first that inside the tube there is a perfect vacuum. Connect a battery; its negative terminal to the potassium coating and positive terminal to the ring, and in circuit therewith a sensitive current-measuring instrument.

When light falls on the active surface electrons are emitted. These negative particles of electricity, free to move in the evacuated space, are attracted to the metal ring which the battery keeps positive; and thus they stream through the wires and in the measuring instrument indicate a current. A current of electricity is produced by the action of light; the energy of light, its ability to do work, is converted into electrical energy, into a motion of electrons, which in turn can do work.

No current can flow through the cell except as electrons are released from its photoelectric terminal by the action of light. As fast, however, as electrons are thus emitted they are drawn across to the collecting ring and through the wires to the battery, while others leaving the negative terminal of the battery hasten to replace them. The process continues as long as the cell is exposed to light, and the electrons sweep around the circuit like a widely scattered field of riders in a six-day bicycle race.

At any instant the number of electrons passing any point of the circuit is just the number which at the same instant are emitted from the photoelectric surface. The more intense the light, the greater this emission. In fact, the current is always directly proportional to the light; and if that varies in intensity exactly corresponding variations occur in the current. For that reason the cell may be made the electric eye in a system of television.

OPPORTUNITY FOR STUDENT ACTIVITY IN COMMERCIAL GEOGRAPHY.

By C. W. Blanchard,

Northern High School, Detroit.

With the advent of commercial education in the public schools of the United States, commercial geography became a recognized unit in the average high school commercial course. The first text books on the subject were abbreviated editions of the encyclopedia and world's almanac if one could judge from the nature of the contents. The same attention was given to one country as another regardless of its commercial significance. The suggested examinations and tests were largely a recount of specific facts set forth in the course. There was too much emphasis placed on statistics which might change in a short time and too little emphasis placed on the factors that have to do with the direction and development of commerce.

To some pupils, the course in commercial geography was very dead and uninteresting because of the bone-dry material used in the course. There were others who had a background for the course through travel or special reading which assisted them in a better interpretation of the facts they discovered in the text book. The recitation of such pupils would bring new life and interest to the class recitation. I remember how we were plodding through a text, on Venezuela with little class interest. A man who was well acquainted with the country came in and gave us a talk on the country and then the class wanted to read everything they could find on that interesting country. The chief job, therefore, of the teacher in commercial geography is to show that the subject matter of the course is not within the covers of any text book, that it is all about us in our every day experiences. A visit to a single factory may bring out a large number of factors of value in the course and lend a new meaning and interest.

In order to give each pupil an opportunity for study along the line of his interest or choice, teachers of Northern High school require a term paper or thesis. These term papers usually take the form of an illustrated thesis. Some will give more attention to the illustration of the topic through appropriate pictures, while others will give more attention to the word picture of their subject. Pupils are put on their own resources in getting this information and the training they get in this way

is very much worth while. Separate credit is given on the term paper so there is a special urge to make it as good as possible.

I attach a list of subjects selected for the present semester. It will be seen that they cover a wide range of interests.

AGRICULTURE:
- Milk
- Cattle
- Apples
- Sheep
- Poultry
- Seeds
- Horses
- Old world fruits

MINING:
- Coal
- Diamond
- Oil
- Copper
- Silver

COMMERCIAL INDUSTRIES:
- News Papers
- Rail Roads

MANUFACTURING INDUSTRIES:
- Ice
- Perfumes
- Paper
- Paint
- Tobacco
- Linen
- Rubber
- Ship-building
- Canning
- Silk
- Soap
- Sugar
- Fur
- Meat
- Baking
- Oil Refining

MANUFACTURED PRODUCTS:
- Steel
- Buttons
- Leather
- Cotton
- Lumber
- Automobiles
- Explosives
- Furniture

"WRENOGRAPH" CHECKS BIRDS.

An elaborate electrical device on the order of a potentiometer has enabled S. Prentiss Baldwin, director of the Baldwin Bird Research Laboratory, to tell exactly how much time Mother Wren spends on the nest incubating her eggs and how much time she takes off.

Thirteen minutes appears to be about the average length of the time she can stick on the job but she seldom stays off longer than six minutes. Almost always she broods her eggs all night during the nesting period, though Mr. Baldwin has a record of one flightly female wren that went out for the evening at 8:50 p. m. and did not return until 1:04 a. m. During the last three days of the incubation period the absences are much less frequent but of about the same duration, the ornithologist has found.

The wrenograph, as Mr. Baldwin has christened the instrument, is a thermoelectrical apparatus connected with the electric light circuit that registers the temperature of the nest each time bird goes on and off the edges. A tiny wire is stretched across the eggs. It looks about like a strand of straw from the nest lining. This wire is connected with a self-recording instrument in the laboratory that registers on a chart the temperature accurate to within one degree Fahrenheit. It is probably the first time that such apparatus has been used to obtain accurate information about the life history of birds.—*Science News-Letter.*

CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

The Monthly Message

Dear Association Friends:—

Our General Officers. Your attention is called to the minutes of our Annual Meeting at Detroit, printed as the official report on another page. To begin with, get the names and addresses of the general officers. The one in your territory is your sponsor. The officers are pleased to serve you.

Our New Treasurer. For a number of years Mr. W. G. Gingery, of Indianapolis, served faithfully and efficiently as our Treasurer. He is now a high school principal, and this promotion together with many outside duties caused him to relinquish his office. *Mr. Ersie S. Martin, Arsenal Technical High School, Indianapolis,* has been promoted to be Treasurer and by this time has actively assumed his duties. Members who fail to receive SCHOOL SCIENCE AND MATHEMATICS, or who desire any special information regarding their membership, should write to the Treasurer. Kind reader, if you are in arrears, or if you are not a member, send in your check for $2.50 and you will see how prompt the new Treasurer can be.

The Hall of Fame. This Association consists of a large and ever growing membership of teachers in secondary schools. These teachers represent a social group among whom high scholarship, progressive experience, and special attainments are at a premium. Members who receive wide recognition for some distinguished work in the educational field are an asset to our Association. We want to show our appreciation of them in these columns. During the past year Mr. M. J. W. Phillips, of the Lincoln High School, West Allis, Wis., won the national Sachs Prize of $1,000.00 given at Columbia University for the best essay submitted on Progressive Methods of Teaching Science. Mr. Phillips has been an active member of this Association for years and served as chairman of the Physics Section last year.

The Mathematics Section. Our last Year Book listed 27.4% of the membership as mathematics teachers. Of those who dropped their membership during the past year 30% were mathematics teachers. This indicates that the mutual relations between the activities of Science and of Mathematics teachers is real and enduring. A year ago, when a committee, headed by F. E. Goodell, was appointed to report on the organization of a National Council of Science the impression was formed in some cities that this Association was planning to limit itself to the field of Science. This is erroneous. It is hoped that a National Council of Science will ultimately be formed by the federated action of associations such as ours. This will in no way affect the dual character of our Association.

W. F. ROECKER, President.

Boys' Technical High School, Milwaukee, Wis.

PROBLEM DEPARTMENT.

CONDUCTED BY C. N. MILLS,
Illinois State Normal University, Normal, Ill.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem, sent to the Editor, should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to C. N. Mills, Illinois State Normal University, Normal, Ill.

LATE SOLUTIONS.

983. *Franklin A. Butter, Jr., San Jose, Calif.*
985. *Gilbert Peters, Roosevelt H. S., Chicago, Ill.*

SOLUTIONS OF PROBLEMS.

986. *Proposed by George Sergent, Tampico, Mexico.*

Given a frustum of a right circular cone, the radii of the bases being a and b, and the altitude h. On the line joining the centers of the bases, a point is taken as the vertex of two cones whose bases are, respectively, the bases of the frustum, and such that their lateral surfaces are equivalent. Determine the position of the common vertex.

Solved by Franklin A. Butter, Jr., San Jose, Calif.

Let a and b be the radii of the lower and upper bases. Let x be the altitude of the cone having a as radius of base; and then $(h-x)$ is the altitude of the other cone. Setting up the equality for the lateral areas we have

$$\pi a\sqrt{a^2+x^2} = \pi b\sqrt{b^2+h^2-2hx+x^2}.$$

Simplifying gives a quadratic in x, from which we get

$$x = \frac{b^2h - \sqrt{a^4b^2+a^2b^4+a^2b^2h^2-(a^6+b^6)}}{b^2-a^2}$$

rejecting the positive sign of the radical, since x is less than h. For a real solution the value of the radicand must be positive, or

$$a^2b^2(a^2+b^2+h^2) > (a^6+b^6).$$

$$h^2 > \frac{a^6+b^6-a^2b^2(a^2+b^2)}{a^2b^2}.$$

$$h^2 > \frac{(a^4-2a^2b^2+b^4)\,(a^2+b^2)}{a^2b^2}.$$

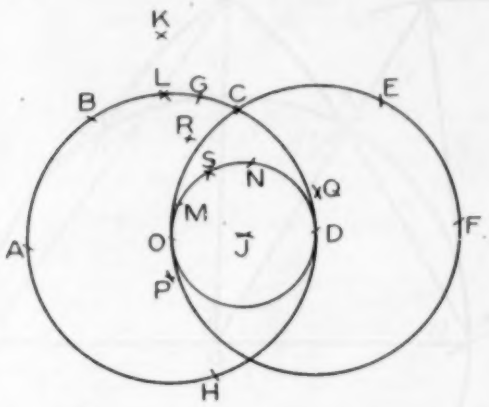
$$h > \frac{(a^2-b^2)\sqrt{a^2+b^2}}{ab}.$$

Also solved by *M. W. Coultrap, Naperville, Ill.; Harry Sohon, Schenectady, N. Y.; Marquess Wallace, Mexico, Mo.; Bessie Green Andrews, Wichita, Kansas; Alice A. Walker, Blackfoot, Idaho; Michael Goldberg, Washington, D. C.; R. T. McGregor, Elk Grove, Calif.; Tillie Dantowitz, Philadelphia, Pa.;* and the *Proposer.*

987. *Proposed by E. dela Garza, Brownsville, Texas.*

In a given circle, with compasses only, construct the side of a regular inscribed decagon.

I. *Solved by Michael Goldberg, Washington, D. C.*



Given circle with center O, step the radius around the circumference three times locating the points A, B, C, D. (If the center of the circle is not given, it may be found by the method given in my paper on "Compass Constructions" which appeared in SCHOOL SCIENCE AND MATHEMATICS, December, 1925, and in my solution of Problem No. 946, March, 1927.) With the same radius, and with center D, draw a circle, and step the radius around the circumference locating E and F. With center F, and radius OF, draw an arc cutting the given circle in G and H. With G and H as centers, and radius OG, draw arcs intersecting in J. Then J is the inverse of F with respect to the given circle and OJ = ½ OG since OF = 2 OG. With center J, and radius OJ, draw a circle.

Bisect BC as follows. (Similar to Problem No. 946, "To bisect a given arc by means of only compass.") With centers A and D, and radius AC, draw arcs interesecting in K. With centers A and D, and radius OK, draw arcs intersecting in L. Then L is the midpoint of BC.

With center L, and any convenient radius, draw an arc cutting the small circle in M and N. Then bisect MN by drawing arcs so that PJ = JQ = MN, MP = NQ = OJ, PR = QR = PN, PS = QS = RJ. Then S is the midpoint of MN and is the intersection of the line LJ with the small circle.

Then LS is the side of the inscribed decagon, for if the radius is unity, $LJ = \frac{1}{2}\sqrt{5}$, and $LS = \frac{1}{2}(\sqrt{5}-1)$.

II. *Solved by the Proposer.*

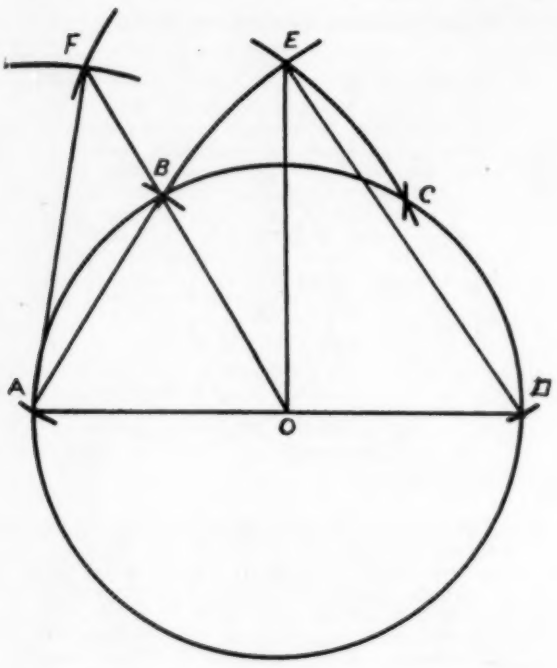
In the given circle, with the radius of the given circle, mark points A, B, C and D, which are the vertices of the regular inscribed hexagon. From A and D, as centers, with radius AC or DB, draw two arcs intersecting at E. From A and C, as centers, with radius OE, draw two arcs intersecting at F. Then BF is the side of the regular inscribed decagon.

Proof. Points O, B and F are collinear. In the triangle EOD, $EO^2 = DE^2 - OD^2$. $DE = DB = R\sqrt{3}$. $OD = R$. Hence $EO = R\sqrt{2}$. Since AF = EO, then $AF = R\sqrt{2}$. $\angle ABF = 120°$. For the triangle ABF

$$(AF)^2 = (AB)^2 + (BF)^2 - 2(AB)(BF)\cos 120°.$$

Substituting the values for AF, AB and cos 120°, we get after rearranging $(BF)^2 + R(BF) - R^2 = 0$. Solving, $BF = (R/2)(\sqrt{5}-1)$ which is the side of the regular inscribed decagon, expressed in terms of the radius of the given circle.

Also solved by *A. E. Breece, Hughes H. S., Cincinnati, Ohio; George*



Sergent, Tampico, Mexico; Walter H. Carnahan, Harry Mayer, Shortridge, H. S., Indianapolis, Ind.

988. *Proposed by Arnold Lebow, Brooklyn, N. Y.*

Solve geometrically the following system of equations.

$$\begin{aligned} x^2+y^2-mxy &= a^2 \\ x^2+y^2-nxz &= b^2 \\ x^2+y^2-pyz &= c^2. \end{aligned}$$

Solved by the Proposer.

To find the sides of a triangle when angles and distances of vertices to a given point are known:

Draw OM, ON, OP, respectively, perpendicular on the sides of triangle. The three circles described with OA, OB, OC, as diameters, pass evidently through M, N, P. It follows that MN is the chord of a circle of known radius and corresponding to a known angle C; consequently, MN can be determined by a simple construction. The same applies to NP and PM. Once we have the sides of triangle MNP, this triangle can be graphically constructed. We proceed next to find point O. This is the intersection of three circles, passing through MN, NP and PM, so that the sides being considered as chords in these circles, they will correspond to the three known angles, A, B and C. This is again an elementary construction. Drawing perpendiculars to OM, ON and OP, these perpendiculars will be the sides of the triangle. The algebraic calculation of the unknown is rather complicated. In triangle MON the side MN is known from first construction above referred to, and it is easily seen its value is $c \sin C$ where $c = OC$. Angle MON is the supplement of known angle C. With $OM = x$, $ON = y$, and $OP = z$, the three triangles MON, NOP, POM lead to the three equations:

$$\begin{aligned} x^2+y^2+2xy \cos C &= c^2\sin^2 C \\ y^2+z^2+2yz \cos B &= b^2\sin^2 B \\ x^2+z^2+2xz \cos A &= a^2\sin^2 A. \end{aligned}$$

The most ingenious way to solve above system would still lead to an equation of third degree. The graphical solution is, therefore, to be preferred. Moreover, we may look at this graphical solution as a geometrical means of solving the simultaneous system of the three equations given above. A remarkable suggestion is that the system:

$$\begin{aligned} x^2+y^2-mxy &= a^2 \\ x^2+z^2-nxz &= b^2 \\ y^2+z^2-pyz &= c^2 \end{aligned}$$

where m, n and p are <1 can be solved graphically, for we can evidently assume $m = \cos D$, $n = \cos E$, $p = \cos F$. We would start by constructing a triangle MNP, having a, b, c as sides, and the problem would be to find a point O in this triangle, so that MON = D, NOP = E, POM = F.

989. *Proposed by Orville F. Barcus, Columbus, Ohio.*

Show that the Pell equation

$$y^2+(2^n+1)y+2^{2n-3} = x^2$$

is satisfied by integral values $y = 2^{2n-3}$, $x = 2^{n-1}(2^{n-2}+1)$.

Solved by Tillie Dantowitz, Philadelphia, Pa.

Substituting the given value of y in the left member of the equation gives

$$2^{4n-6}+2^{3n-3}+2^{2n-3} = x^2.$$

Hence $x^2 = 2^{2n-3}(2^{2n-4}+2.2^{n-2}+1)$.

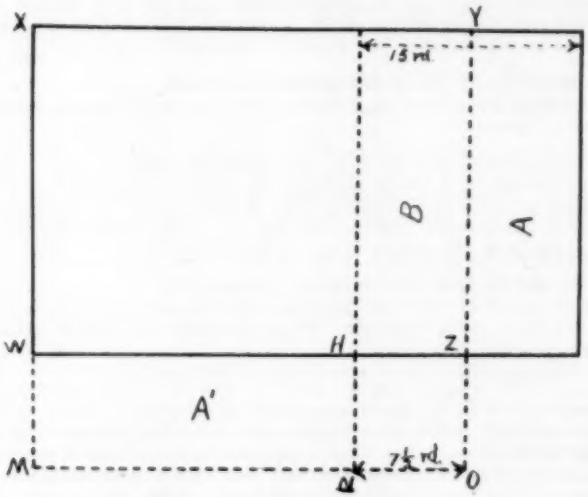
Then $x = 2^{n-1}(2^{n-2}+1)$.

Also solved by *Franklin A. Butter, Jr., San Jose, Calif.; Michael Goldberg, Washington, D. C.; R. T. McGregor, Elk Grove, Calif.; Paul Mount Campbell, Monte Vista, Cal.;* and the *Proposer.*

990. *Proposed by the Editor. For High School Pupils.*

A rectangular field is 15 rods longer than wide, and has an area of 8 7-16 acres. Find the length and width. Do not use algebra.

I. *Solved by Arnold Brother, Lewis and Clark H. S., Spokane, Wash.*



Since the length of the rectangle is 15 rods longer than the width, a square can be constructed with a side equal to the width. A rectangle is left whose width is equal to 15 rods and whose length is the width of the original rectangle. Divide the last rectangle into two equal rectangles A and B. The width of each is 7.5 rods. Place rectangle A in the position of A′ and extend YZ and MN until they meet at O, making the square

XYOM, which has an area of 1406.25 square rods. XY = 37.5 rods, hence the length of the original rectangle is 45 rods and the width is 30 rods.

II. *Solved by George Sergent, Tampico, Mexico.*

The number of square rods in the rectangle is 1350, which number is the product of two factors. One of the factors is even, and one of them at least is a multiple of 5, for their product is a multiple of 10. $1350 = 2\times3^3\times5^2$. Since their difference is a multiple of 5, both are multiples of 5.

Dividing both factors by 5, divides their product by 25, and their difference by 5. Hence $1350/25 = 54$, and $15/5 = 3$. The two factors of 54 whose difference is 3 are 9 and 6. Therefore 9×5 equals 45 rods the length, and 6×5 equals 30 rods the width.

III. *Solved by the Editor.*

Arrange four such fields in the form of a square so that the short side of one is against the long side of the other. The side of the small central square is 15 rods, and its area is 225 sq. rd. The area of the large square thus formed is 5625 sq. rd., and its side is 75 rd. Hence the width of the original rectangle is $\frac{1}{2}$ of $(75-15)$, or 30 rods, and the length is 45 rods.

Also solved by *Eva Brostoff, Roosevelt H. S., Chicago, Ill; F. A. Butler, San Jose, Calif.*

PROBLEMS FOR SOLUTION.

Editor. More problems have been selected which ought to appeal to the High School Pupils. Hereafter such problems will not be specifically marked.

1001. *Proposed by F. A. Cadwell, St. Paul, Minn.*

Without bisecting any angle, draw a line parallel to the base of a triangle and terminated by its sides so that it shall be equal to the sum of the segments of the sides adjacent to the base.

1002. *Anonymous.*

What are the chances in a bridge game: (1) that one player shall be dealt a hand containing all the cards of one suit, (2) that each player shall be dealt a hand containing only cards of one suit?

1003. *Proposed by M. W. Coultrap, Naperville, Ill.*

Find a number such that its square, when increased or decreased by 5, will remain a square.

1004. *Proposed by George Sergent, Tampico, Mexico.*

To cut a sphere by a plane so that one of the segments has a volume equal to that of the cone whose vertex is the center of the sphere and whose base is the section determined by the plane in the sphere. How far is the plane from the center of the sphere?

1005. *Proposed by Marquess Wallace, Mexico, Mo.*

From any point on the circumcircle of a triangle, perpendiculars are drawn to the sides of the triangle. Prove that the feet of the perpendiculars are in a straight line.

Editor. This is called the *Simpson line of a triangle.*

1006. *Proposed by F. P. Hennessey, New York City.*

A man, in his will, left a circular plot of land of 500 acres, to be divided among his wife and four sons. Each son was to receive as much land as is contained in one of the four equal circles that can be inscribed in the circular plot; the wife to receive all that remained. What was each son's share and the wife's share?

Scholarships for study abroad to the four students having the best records in secondary schools of Costa Rica will be given by the board of directors of secondary education. The scholarship provides $60 a month each and $100 for tuition fees. Beneficiaries are expected to return to Costa Rica to teach in secondary schools.

SCIENCE QUESTIONS.

CONDUCTED BY FRANKLIN T. JONES.

Questions for discussion, examination papers, disputed points may be submitted to this department. They will be published together with discussion.

Please let us know what you are working on. It will be helpful to pass the information along.

Send all communications to my home address—Franklin T. Jones, 10109 Wilbur Ave., Cleveland, Ohio.

ACKNOWLEDGMENTS.

Examination papers have been received from Charles M. Turton, Bowen High School, Chicago, Ill., C. W. Weaver, High School, Grafton, W. Va., H. G. Johnson, Greenbush High School, Greenbush, Minn., Department of Education, Ontario, Canada, Boston University, Boston, Mass., Rensselaer Polytechnic Institute, Troy, N. Y., Massachusetts Institute of Technology, Cambridge, Mass., and McGill University, Montreal, Canada.

EXAMINATION PAPERS.

Submitted by H. G. Johnson, Greenbush H. S., Greenbush, Minn.

I am enclosing a copy of a true-false test on electricity and magnetism that I gave my pupils last winter. It can be given to both Physics and General Science pupils whenever they get through with the study of electricity.

Although I question whether true-false tests are very accurate measurements of a pupil's knowledge in a subject, I believe that they are of great value if intermixed with other types of tests. They consume little time, and if all the statements are gone over in class after the papers have been handed back, the pupils will acquire a great deal of information concerning specific facts that are worth knowing.

The pupils may indicate whether the statements are true or false by putting a plus sign in front of the number of the statement if true, and a minus sign if false.

TRUE-FALSE TEST ON ELECTRICITY AND MAGNETISM

1—The north pole of a magnet attracts the south pole of a compass needle.
2—A wire carrying an electric current becomes magnetised.
3—Silver is a poorer conductor of electricity than copper.
4—Glass is a very good conductor of electricity.
5—The magnetic pole of the earth lies about 70 degrees N. latitude and 96 degrees W. longitude.
6—In Minnesota the compass needle points nearly directly north.
7—In Alaska the compass needle points in a north-easterly direction.
8—The north star is directly above the magnetic north pole.
9—Like poles of a magnet attract each other.
10—Henry discovered the electro magnet.
11—Faraday discovered the principle of the dynamo.
12—Edison made the first carbon electric light lamp.
13—Watt invented the lightning rod.
14—A transformer is used to change the voltage of a current.
15—To transmit a current a long distance a high voltage is cheapest.
16—A direct current cannot be stepped down by a transformer.
17—The alternating current is used on high voltage lines.
18—The purpose of the fuse is to guard against too strong a current.
19—Porcelain is a good insulator.
20—An ammeter measures the amount of current.
21—Two of the most important things in a dry cell are sulfuric acid and lead peroxide.
22—The tungsten lamp is cheaper to operate per candle power than the carbon lamp.

23—The spark plug furnishes the spark to ignite the gas in a gas engine.
24—Electrical power is measured in ohms.
25—The principle of the electric light lamp is that when a current passes through a wire the wire becomes hot.
26—For small power the electric motor is a great deal more convenient and cleaner than the gas engine.
27—Queen Elizabeth's maid used an electric iron to press her majesty's dresses.
28—Ohm's law states that the current in a wire is equal to the E. M. F. divided by the resistance.
29—In order to electroplate anything you must have a solution of the thing that you wish to put on.
30—A solution of copper sulfate may be used for copper plating.
31—The strength of a storage battery may be tested with a hydrometer.
32—The dry cell may be tested with a voltmeter.
33—The electromagnet is used in an electric bell.
34—Without electricity we would not have the telephone.
35—To connect cells or batteries in series opposite posts are connected.
36—The number of watts is equal to the volts times the ohms.
37—To find the amount of electricity used up in a month you subtract the reading of the meter last month from the reading this month.
38—There are no permanent magnets in a dynamo.
39—There is a commutator in the telephone receiver.
40—The mouth piece of the telephone contains the small carbon granules.
41—Radio waves are electrical waves.
42—Lightning is caused by clouds carrying charges of electricity.
43—A short circuit is caused by a wire or some other conductor taking most of the current so that very little or none flows the course it should take.
44—An open circuit is one in which the wires or connections are broken at one or more points.
45—Dry cells should be connected in series for a doorbell circuit.
46—Telegraph wires are made of iron instead of copper because iron is a better conductor of electricity.
47—Columbus was the first sailor to make use of the compass.
48—If a magnet is dropped on the floor, it may lose some of its magnetism.
49—A current of about te amperes is used in electrocuting criminals.
50—A voltage of 400 volts may be dangerous to human life.

DEPARTMENT OF EDUCATION, ONTARIO.

ANNUAL EXAMINATIONS, 1927

MIDDLE SCHOOL

PHYSICS

1. Describe experiments, one for each, to show:—
   (*a*) That water is a poor conductor of heat.
   (*b*) That a dark, rough surface will radiate heat more rapidly than a light-coloured, smooth surface.

2. 100 grams of water at 50°C. and 100 grams of mercury at the same temperature are each poured into separate cuplike hollows in a block of ice at 0°C. and covered with ice. What weight of ice will be melted in each case? (Specific heat of mercury = 0·033; heat of fusion of ice = 80 calories.)

3. Describe and explain what takes place when a piece of copper wire gauze is brought down upon the flame of a Bunsen burner or a spirit lamp. Show how the principle which this experiment illustrates is made use of in the Davy safety lamp.

4. Describe experiments, one for each, to show:—
   (*a*) That a medium is necessary for the transmission of sound.
   (*b*) How the velocity of sound in air may be determined.

5. Explain by means of diagrams in which the position of the eye is shown:—

(*a*) How the eye sees the image of an object placed in front of a plane mirror.

(*b*) How a convex lens may be used as a simple microscope.

6. Describe a grease-spot (Bunsen) photometer and explain its use.

7. (*a*) Describe a laboratory method of determining the presence and the direction of an electric current passing through a wire.

(*b*) State the use of (i) the ammeter, (ii) the voltmeter. Describe the construction of *either* of these instruments.

8. Describe a gold leaf electroscope and explain how it may be used to determine the nature of the charge on an electrified body.

9. Describe a simple alternating current transformer. Explain the principle of its action and state the reason for its use in the distribution of electric power.

10. (*a*) Describe what takes place when an electric current is passed through a solution of copper sulphate between copper electrodes.

(*b*) How may the process in (*a*) be used to measure the strength of an electric current?

DEPARTMENT OF EDUCATION, ONTARIO

ANNUAL EXAMINATIONS, 1927

UPPER SCHOOL

PHYSICS

1. In a laboratory experiment a body weighing 1000 grams moves along a horizontal plane and the distances travelled over during successive intervals of one-tenth of a second each are: 5·0, 8·2, 11·2, 14·4, 17·5, 20·7 cms. Find:—

(*a*) The value of the average acceleration in cms. per sec. per sec.

(*b*) The value of the force in grams weight acting on the mass along the line of its motion.

2. Below is a drawing of a four-inch scale divided into tenths of an inch and an attached vernier scale. Find as exactly as you can the reading of the zero of the vernier, and give reasons for your answer.

3. (*a*) State Newton's third law of motion. Illustrate by reference to any experiment or practical experience just what is meant by the terms used in this law.

(*b*) Explain how and why the milk and cream are separated in the cream separator.

4. (*a*) Several forces in the same plane act upon a rigid body. What conditions must be fulfilled in order that there may be no translation and no rotation of the body?

(*b*) A uniform ladder 30 feet long is resting against a smooth vertical wall, the top of the ladder being 20 feet from the ground. The foot of the ladder rests on the ground and against a peg driven into the ground. If the ladder weighs 100 pounds, find the force exerted by the peg. (Disregard the friction of the ground.)

5. (*a*) Explain what is meant by the coefficient of friction between two surfaces, and state explicitly the meaning of any symbols you use.

(*b*) Outline an experimental method of finding the value of the coefficient of friction.

(*c*) What is the least force that must be exerted on a trunk weighing 200 pounds in order to cause it to slide up a gang-plank which makes an angle of 30° with horizontal? (Assume that the force is parallel to the gang-plank and that the coefficient of friction equals $\frac{1}{3}$.)

6. (*a*) Define: dyne, erg, gram weight, watt, kilowatt-hour. In each case tell whether the term is a unit of force, work, or power.

(b) Give an outline of the experimental evidence that one calorie of heat is equal to $4{\cdot}2 \times 10^7$ ergs.

(*c*) Four incandescent lamps each using $\frac{1}{2}$ an ampere of current were left burning, by mistake, from 11 p. m. to 7. a. m. next morning; find the cost of the mistake if the cost of electrical energy is 2 cents per kilowatt-hour. (The voltage is 110.)

7. (*a*) What is meant by the hydrostatic paradox? How is it explained?
(*b*) How would you show experimentally that Archimedes' principle is true for water?
8. (*a*) State how you would show experimentally:—
(i) That air has weight.
(ii) That the pressure in a moving column of liquid varies with the velocity.
(*b*) When a canoe is travelling down a rapid current it always tends to keep in the water which is moving most swiftly. Explain why this is so.
9. (*a*) Describe the ordinary siphon, explaining its principle of action.
(*b*) Describe the method of finding the surface tension of water by use of the capillary tube.

QUESTIONS AND PROBLEMS.

Proposed by Wallace C. Swank, Eaton Rapids, Mich.

508. Why do we consider sweet is the opposite of sour?

SOLUTIONS AND ANSWERS.

500. Explain why it is one can "pump up" in a swing.

Submitted by Wallace C. Swank.

Answer by M. F. Prue, North Tarrytown, N. Y.

Dear Mr. Jones:—

The December SCHOOL SCIENCE AND MATHEMATICS Question department, of which you are Editor, caught my attention instantly. No. 500, Mr. Swank's query, involved the principle of the pendulum. I offer the following explanation.

The swing is a pendulum, divided into a long and a short segment by the hands of the person swinging. When we grasp the rope and force the seat to move forward and up, we raise the "bob," so to speak, and the point where we grasp the rope becomes momentarily the point on which the pendulum swings. The height being reached, stress on the rope is released and the "bob" falls to the initial position, the whole swing now acting as the pendulum and carrying the boo across the lowest point and part way up on the other half of the arc. Then again the short pendulum segment is brought into play, thereby carrying the bob slightly higher in the arc. This, of course, causes a larger arc to be made.

Answer by William I. Foster, Rochester, Minn.

If the person swinging raises his center of gravity at the middle point of the motion, the radius of angular motion is shortened and the amount of inertia decreased. The angular momentum at this position is constant as the resultant of the external forces is zero. Therefore the angular velocity must increase to keep the angular momentum constant with a decrease in moment of inertia. At the end of the swing where the velocity is zero the angular momentum will also be zero and the lengthening of the radius of motion does not affect the motion. When the center of gravity is raised at the point of maximum velocity, work is done against centrifugal force, and this is the work that supplies the energy. Then the things necessary to "pump up" are to raise the center of gravity at the middle of the swing and lower it at the end.

CORPORATION SCHOOL ALLIED WITH UNIVERSITY.

Academic recognition of advanced engineering courses conducted by the Westinghouse Company is given by the University of Pittsburgh. Certain Westinghouse engineers in responsible charge of the courses are recognized by the graduate school of the university as faculty members, and courses offered by the educational department of the company may be counted for graduate resident credit at the university. Research work and resulting theses may be carried out under the direction of Westinghouse engineers who are accorded this recognition. So far 85 men have enrolled for this specialized work.

COAL IN NORTHEASTERN WYOMING.

The Gillette coal field, in northeastern Wyoming, contains over 14 billion tons of coal in workable seams, according to a report recently issued by the Geological Survey, Department of the Interior, as Bulletin 796-A. The huge tonnage of this single coal field may be compared to the total amount of coal mined to date from all the coal mines in the United States —17,800,000,000 tons. Two of the Gillette coal beds are together 75 feet thick.

This coal field is described in the report by geologists C. E. Dobbin, V. H. Barnett, and W. T. Thom, Jr., which may be obtained from the Superintendent of Documents, Washington, D. C., for 35 cents. The field lies principally in Campbell County but includes also parts of Crook, Weston, Niobrara, and Converse counties. It contains several country mines and prospects from which small quantities of coal have been obtained for domestic use, and some of the ranchers mine their own coal from the nearest outcrop, usually a bluff along some stream where the weathered coal is kept washed away by freshets.

Since the discovery west of Minturn of the thick Roland and Smith beds, aggregating there an average thickness of 75 feet, interest in the exploitation of the coal on a larger scale has been aroused. Exploration has shown that so great a tonnage of coal can be mined by stripping west of Minturn that demand for coal is the only factor limiting the number of mines that can be profitably opened and operated in the district. All points in the Gillette field are within 60 miles of the nearest railroad shipping point. The northern part of the field, which includes the Minturn district, is crossed by the Chicago, Burlington & Quincy Railroad. The southern border lies about 25 miles north of the Chicago & Northwestern Railway line between Casper and Lusk.

The coal, which burns readily, is of low subbituminous rank and belongs to a class which has often been referred to as black lignite. It is roughly similar in character, adaptability, and geologic age to that of the Lost Spring and Sheridan fields, which is used by the Chicago & Northwestern Railway and the Chicago, Burlington & Quincy Railroad, respectively, in specially built locomotives. In general the coal from the Gillette field is rather tough, and some of it shows the structure of the wood from which it originated. Fresh pieces, when exposed to the air, lose moisture and as a result soon check and crumble. Like the subbituminous coal of other fields, the Gillette coal tends to take fire spontaneously when exposed to the weather in outcrop or in large storage or culm piles. In consequence of this tendency and of the disintegration produced by the loss of moisture, bulk storage of the coal presents special technologic problems. Moreover, as water composes nearly one-third of the weight of this coal as mined any process that can be applied cheaply to remove the moisture and valuable oils and other by-products from the coal before shipment will not only reduce freight charges and increase the radius within which it can be marketed but will possibly also open a profitable field in by-product recovery.

Most of the coal reserves of 14,500,000,000 tons in this field can be recovered by stripping. Coal of a slightly superior rank and heating value is now being mined in this way on a large scale south of Forsyth, Mont., for use as locomotive fuel, and it is reported that stripping operations are soon to be begun near the Peerless mine, near Minturn.

A considerable part of the coal in the Gillette field is owned by the United States and is subject to development under Government lease in accordance with the provisions of the act of February 25, 1920, commonly known as the mineral leasing law.—Department of the Interior.

BROWNIAN MOVEMENTS WITH LOW MAGNIFICATION.

By W. M. Cady, *Middletown, Conn.*

A subject in which very little can be done in the way of class demonstration is the study of molecules. The most direct and convincing evidence we have that matter is molecular is that afforded by the Brownian movement. Yet even this demonstration has been denied many high schools because of the high magnification hitherto necessary. Within recent months, however, a method has been devised whereby powers as low as ten reveal the movement, though of course better results are attained by the use of somewhat higher power.

The suspension used, consisting of small flakes of common transparent mica in clean water, is prepared as follows. A fairly stiff slab of mica is pressed edgewise against a dry rapidly rotating emery wheel until a quantity of impalpable dust has been obtained. This dust is stirred into a graduate of water and allowed to stand for about four hours. The larger flakes having settled to the bottom, the thin milky suspension is siphoned off, care being taken not to draw off any of the useless residue at the same time. Even the small flakes that are in suspension after four hours will eventually settle out, and the bottle containing them and the water must be shaken before use.

The mica water is placed between the microscope slide and coverglass, both of which must be very clean and free from scratches. The slide is then set on the stage of the microscope as usual, but the illumination, which should come entirely from below, must be so oblique that none of the light passing up through the slide can enter the microscope tube. This obliquity is accomplished by swinging the substage mirror to one side.

The appearance then presented in the dark field of view is analogous to that of a Christmas tree in the sunlight, decorated with small hanging mirrors which are swaying irregularly. The mirrors (mica flakes) twinkle in the sunlight (substage illumination) as they are rotated irregularly by the wind (molecular bombardment). The analogy breaks down, however, when we consider the lateral movement. The mirrors on the tree are anchored, but the mica flakes are, of course, free to undergo migratory movements, which can be seen under higher powers. The larger flakes are joggled less, but reflect more light. Thus the smaller bright points in the dark field of view twinkle more rapidly than the larger points.

This method, then, consists in essence in observing rotational Brownian movements of mica flakes suspended in water by means of a low power ultra-microscope.

STIMULATING INTEREST IN CHEMISTRY.

By D. C. Barrus,

Mount Hermon School, Mount Hermon, Mass.

Any device for permanently interesting a student must be founded upon some basic principle. The following plan which the class frequently employs seems sound as it is based upon the principle of self-activity as an essential to growth.

It will be assumed that the class is studying the topic of aluminum. The teacher will designate some student to be prepared at the next recitation to demonstrate some of the properties and tests of the metal. The teacher urges the other pupils to be prepared to ask questions that can be answered by simple experiments.

When the designated recitation hour comes the student takes his place at the lecture table with an adequate supply of test tubes and reagents prepared to make the simple demonstrations.

Some student may ask him to show that the sample is not platinum.

Another may ask him to show that it is not zinc, while some one else may want to know how it can be shown to be aluminum. To each of these questions the student will respond by giving the usual experiment for each.

During the experiments the teacher or any other member of the class will ask about the position of aluminum in the electrochemical series and any other fundamental law involved. Important equations are written.

When a teacher first tries this method it is well to select a high grade student to do the demonstrating. It will not be long before the others will learn how to conduct the experiments. Complicated experiments should be avoided as the class will usually lose the main teaching of each. As a rule the writer has found the majority of the members of the class anxious to have a part in the class room work in this way.

BOOK REVIEWS.

Algebra to the Quadratic, by R. W. Gibbs. Pp. 140+160. 13x19 cm. 1927. Oxford University Press. $1.00.

This book is divided into two parts. The first part contains textual matter consisting of definitions, discussions, and illustrative problems. The author has aimed to write it in a form so simple that it may be read and understood by young pupils.

The second part contains sets of exercises corresponding to the sections of the first part. For the most part each exercise is divided into two parts, A and B.

Algebraic symbols are skillfully introduced in the first chapter. Negative numbers are introduced in the second chapter. One chapter is devoted to the formula and another to graphs. J. M. Kinney.

Analytic Geometry, by Thomas E. Mason, Professor of Mathematics, Purdue University, and Clifton T. Hazard, Associate Professor of Mathematics, Purdue University, with the Editorial Cooperation of Professor R. D. Carmichael of the University of Illinois. Pp. xi+224. 14.5x21.3 cm. 1927. Boston: Ginn and Company. $2.40.

The authors have presented this course in Analytic Geometry in the conventional form with the exception that the chapter on the straight line precedes the chapter on the equation and locus. This seems to be good pedagogy, since the student has had some experience in constructing graphs of straight lines, and since it offers an easy introduction to the problems of finding the graph of an equation and the equation of a graph.

This book is well supplied with exercises for drill and with problems which may be selected by the instructor to meet the needs of students of varying degrees of ability. J. M. Kinney.

Healthful Living, by Jesse Feiring Williams, Professor of Physical Education, Teachers' College, Columbia University, Pp. viii + 596, 322 figures and twelve full-page plates. The Macmillan Company. Revised edition, 1927.

In considering a modern text-book in human physiology, it is interesting to note that at one time physiology in the schools, even in the grades below the high school, was merely the teaching of anatomy. As the texts improved and the method changed, function was emphasized, and in many texts to-day the presentation of function is the goal of endeavor. The modern text-book which is of greatest help considers structure and function of the body only in so far as such treatment forms a basis for a knowledge that will help the boy or girl to live a finer and more vigorous life or lays the foundation for further study in this field.

The author sets forth what he calls the rules of the game and states that the facts about the human body that one needs to know to carry out the rules with intelligence are to be gained from a study, such as is offered in this text. The seven rules specifically dealt with are concerned with outdoor air, wholesome food in proper amounts, intelligent

care of the body, rest and sleep, thinking straight, prevention of infection and physical activity.

The subject-matter of each chapter is preceded by an outline of the material of the chapter. This is of advantage in giving a preview of the subject and in reviewing the work before leaving the discussion of a subject. At the end of the chapters are lists of practical questions and exercises are suggested for laboratory work. A glossary is provided at the end of the text. The book should prove an excellent text for classes in the high school physiology. Information, such as this text gives, should be a part of the equipment of every high school graduate.

Jerome Isenbarger.

Laboratory Manual for Elementary Botany, by Edmund W. Sinnott, Professor of Botany, Connecticut Agricultural College. Size 15x23 cm. Cloth. Pp. 106+ix. Published by McGraw-Hill Book Company, Inc. 1927. Price $1.00.

Professor Sinnott is author of "Principles and Problems" of Botany, an elementary college text, which this laboratory manual is designed to accompany. We find the book beautifully printed and the entire make-up of the book a credit to any publisher.

The exercises include a series of studies of plants such as one would naturally expect for the purpose for which it is written. The style is clear and direct without unnecessary details and words. In fact, the exercises are admirable in every way. Secondary school teachers can get much help and many suggestions for their work from the book. W.W.

Plant Respiration, by Dr. S. Kostychev, Professor in the University of Leningrad, translated and edited by Charles J. Lyon, Ph.D., Assistant Professor of Biology at Dartmouth College. Authorized edition in English. Cloth, 15x23 cm. in size with xi+163 pages, illustrated. Published by P. Blakiston's Son & Co. 1927. Price $2.50.

The Russian physiologist, Professor Kostychev, has long been an active worker in the problems of respiration and is well qualified to present this well-balanced discussion of the experimental work in this field of knowledge. Some of the subjects discussed are: "Oxygen Respiration," "Anaerobic Respiration," "Chemical Processes in Plant Respiration," and "Respiration at the Expense of Mineral Substances."

This is a book for the student rather than for the general reader of science. It will be welcome to those who wish to keep informed on this important subject. W. W.

Applied Physics—A Laboratory Manual by W. D. Henderson, Ph.D. 26.5 cm.x19.5 cm. Cloth. Loose leaf. Lyons and Carnahan, Chicago and N. Y. 75 cents.

This is a high school physics manual containing sixty experiments, most of which one would expect to find in a collection of experiments that have become standard in the teaching of secondary physics in American schools. The distribution of the experiments is: Measurements, 6; Mechanics of Solids, 9; Mechanics of Liquids, 8; Heat, 9; Sound, 5; Light,6; Magnetism, 1; Electricity, 16.

One of the merits of the manual lies in its simplicity. Each experiment emphasizes one idea. The directions are given in a simple manner. Data are to be recorded in tabular forms already prepared. A few pertinent questions follow each experiment. A critical attitude toward the accuracy of the student's results is encouraged. Only standard form of apparatus procurable from any of the supply houses is necessary for the experiments. Although loose leaf, when assembled, the book has the appearance and the quality of permanency of a bound book.

The manual is not "applied" in the usual sense of that word, for it does not contain any experiments which we would expect to find in a manual bearing the term "applied." It is a good list of experiments involving the principles of secondary physics, clearly written, with tabular forms that economize time, and for a book that has the loose leaf advantages, is solid in construction. There are eleven tables of physical constants in the appendix. R. B. Z.

Analytic Geometry, by Clyde E. Love, Professor of Mathematics, University of Michigan. Pp. xiv+257. 14.3x20.3 cm. 1727. New York: The Macmillan Company.

This book is a revised edition of the one published in 1923. It has been shortened chiefly by omitting matter of an advanced character. The author aims to discourage a mechanical treatment of the subject. His exercises are therefore chosen to a very large extent to provoke thought on the part of the student. J. M. Kinney.

Seashore Animals of the Pacific Coast, by Myrtle Elizabeth Johnson, Professor of Zoology, San Diego State College, California, and Harry J. Snook, Head of Biology Department, Stockton High School, California. Pp. xiv plus 659, 700 figures and eleven full-page color plates. The Macmillan Company. 1927.

This book is a non-technical, illustrated account of the structure and habits of the common seashore animals of the west coast of the United States. The authors have gathered together material from many sources and have made illustrations of most of the species mentioned, with the expressed hope that the reader, although he may not be equipped with a zoological vocabulary, may be able to identify most of his collections by the help of the pictures and the brief text, and that he may find here information on habits and life histories that will be interesting.

With this book, it will not be necessary for naturalists, teachers and others on the west coast to delve into tedious technical scientific literature to get information of a general nature about the animals which they find. The material is compiled here in a single volume.

The first chapter describes collecting grounds and methods of collecting. The second chapter deals with classification, while the third chapter gives a general account of life of the ocean. The remaining chapters of the book are given over to the various phyla of the invertebrate animals of the Pacific Coast. An appendix gives methods of keeping sea animals alive in aquaria and methods of preserving specimens for museum use. An extensive bibliography and a glossary are added.

The book is well written, adequately illustrated, and the printing and binding are in keeping with the high grade of the subject-matter of this work. Jerome Isenbarger.

Textbook of General Zoology, by Winterton C. Curtis, Professor of Zoology, University of Missouri, and Mary J. Guthrie, Associate Professor of Zoology, University of Missouri. Pp. xv plus 585, 308 figures. John Wiley and Sons., Inc., New York. 1927.

This new textbook in college zoology is welcomed by those teachers who favor the type of instruction in general zoology, the essential feature of which is the emphasis placed upon principles rather than upon phyla. A limited number of animals is selected to illustrate certain biological principles and only incidentally as representatives of particular phyla. This is in contrast to the phylum scheme of instruction which is represented by well-known textbooks. Recent discussion of methods of teaching general zoology has largely centered upon the relative merits of these two systems, and has been influenced by certain extreme departures in the attempt to teach principles.

The first fourth of the book is devoted to the principles of vertebrate zoology with special reference to human anatomy and physiology. The purpose of subsequent chapters is to lead the student to see how other animal bodies may be compared with his own and to impart some of the interesting facts about animals. In the final chapters on development, genetics and evolution, there is a return to more human problems.

This text should stimulate a movement to a type of teaching which recognizes that all students who should receive training in zoology in college are not pre-medical students or embryo specialists in zoology. But even for the classes mentioned, should not an introductory study be concerned, primarily, with the principles of animal life? What better basis for specialized study could the student get?

The book will be valuable as a reference in high school biology departments and teachers will find the work stimulative and suggestive as an aid to teaching high school biology. Jerome Isenbarger.

Our Evolving High School Curriculum, by Calvin Olin Davis, Professor of Secondary Education, University of Michigan. Cloth, Pp. ix+301. 13 cm.x19 cm. 1927. World Book Co., N. Y. and Chicago.

Curriculum reorganization has been receiving no little attention of late by leaders in educational thought, by committees of educational organizations, and by the administrative officers of some of the large city school systems. The movement is not only bound to spread, but recognizing, as we frankly must, that the curriculum is an *evolving* thing, the problem of modifying the courses of study to satisfy effectively the needs of the high school pupils will always be with us. It is fortunate for the students of secondary education and for superintendents, principals and other administrative officers that there is available a guide-book, which brings together what has been done by various agencies in the way of the study of the high school curriculum, what have been the guiding principles in these analyses and reorganization, and what forces should and must be recognized in any serious attempt to lay down principles for curricular revision and reorganization.

In order to help the student to understand the present curricular situation, Professor Davis briefly traces the historical development of the curriculum, emphasizing those influences that have molded it during the last half-century in the American schools. Criticism of the schools has led to an insistent demand for a fundamental change in curricular content, and so the present problem. Four directly related problems are discussed: 1. The nature of youth, very briefly; 2. The aims and objectives of high school teaching: what they have been conceived to be by various thinkers, what procedure should be followed to determine valid educational objectives for any school with examples of method already used; 3. The subjects that contribute to the realization of the objectives set up should, of course, be included in the curriculum; but what are the educational values of the various subjects? These values have not as yet been scientifically determined, and the problem is a difficult one, but is admirably and reasonably handled by Professor Davis. 4. The last problem taken up deals with the administrative aspects of curriculur reorganization: the considerations that must be given to individual differences in pupils and to their diverse interests; and what subjects should be prescribed and what subjects left for election. Then follows illustrative material, showing how some schools have met these problems. The concluding chapter contains comparative curricular statistics, showing how subjects in the high school curriculum have changed from time to time and from place to place.

The book is well organized, clearly written, scientific in its attitude and treatment, and particularly adapted for classes in our colleges and normal schools. It is full of dependable information and sound suggestions for the superintendent and the principal. R. B. Z.

Secondary School Curricula, by Willis L. Uhl, Professor of Education, University of Wisconsin. Cloth. Pp. xx+582. 19.5x13 cm. 1927. The Macmillan Company, New York.

The first two hundred pages of this book consist of educational history with emphasis on the types of curricula in the schools of the different civilizations, Greek, Roman, Mediaeval, etc. This provides the educational background for the discussion of the fundamental curriculum problems which were brought to the front by the criticisms of such educational leaders as Socrates, Plato, Petrarch, Erasmus, Bacon, Spencer, Huxley, Eliot and Dewey. A discussion of these criticisms forms the second part of the book. These two parts of the text perform the important function of showing what problems have come up in the past and how they have been solved or left as problems for future solution.

The remaining sections of the book discuss the various steps that are being taken toward a solution of these curricular problems. This includes a discussion of (1) educational objectives, how they are derived, and how they affect curricula: (2) the relation of pupil equipment, interests and needs to curricula; (3) the effects of local conditions on curricula; (4) the present-day reconstruction and administration of curricula. G. W. W.

EXPLORATIONS IN ALASKA.

The Interior Department announces the completion of the field work of another exploratory expedition in Alaska by the Geological Survey and the bringing back of maps and information regarding a tract of more than 2,000 square miles in the Alaska Range and adjacent country on the west side of Cook Inlet, in the environs of Mount Spurr, that has hitherto been shown as a blank area on all authoritative maps. This exploration is one of the series that the Geological Survey has been making throughout the last 30 years. The party consisted of S. R. Capps, geologist in charge, R. H. Sargent, topographic engineer, and four camp men. Transportation in the field of the necessary provisions, supplies, and equipment for 100 days was furnished by a pack train of fifteen horses. From the time when the party landed at Trading Bay, on the west side of Cook Inlet, about the middle of June, until it returned to that place at the end of the field season, about the middle of September, the members were entirely out of communication with the rest of the world and saw no human beings other than one another.

The results of the expedition are now being worked up for publication, but as it will be many months before the reports are completed, it may be of present value to give in advance a statement of some of the notes of greatest general interest regarding the work of the party. Among the many items reported are the discovery and mapping of a large river, numerous lakes, glaciers, and mountains, and an active volcano. The newly discovered large river is the Chakachatna, whose drainage basin covers an area of more than 1,100 square miles. This stream is a roaring torrent far too swift and too deep to be forded even with horses; in fact, measurements of its current at several places showed that it was flowing at an average speed of 15 miles an hour. This river rises in a superb lake, Lake Chakachamna, 23 miles long, which is hemmed in between lofty mountains and impounded behind a great glacier that lies athwart the general trend of the valley. The distribution of the rivers that head against the Chakachatna can now be predicted with considerable assurance. Thus, to the south are rivers that probably flow in part into Lake Clark; to the west and northwest are tributaries of Stony River and of the South Fork of Kuskokwim River.

Many of the mountain peaks are ragged pinnacles which could be climbed, if at all, only with great difficulty. The highest peak of the region is Mount Spurr, which rises to an altitude of 11,000 feet and is clearly visible from the coast. Although the flanks of this mountain are in large part covered with perpetual snow and glaciers, the mountain was found to be an old volcano that is still active. When the weather was favorable a plume of steam could be seen rising from a point near its crest to a height of more than a thousand feet. This discovery therefore establishes Mount Spurr as the most northerly of the long series of known active volcanoes that occur at intervals along the west coast of Cook Inlet and extend westward into the Alaska Peninsula and Aleutian Islands.

The region is exceedingly difficult to traverse because of the swampy lowlands, the raging streams, and the precipitous mountains. Between the coast and the mountains is a lowland about 30 to 50 miles wide that near the large rivers is so swampy as to be impassable for horses during the summer and that in the somewhat higher ground remote from the rivers is in places also marshy and in other places so densely covered with thickets of large alders that even the combined efforts of all the members of the party resulted in chopping out a trail less than a mile long in a day. To build a trail passable for horses across the moraine-covered glacier

that impounds Lake Chakachamna required work with pick and shovel equivalent to the work of one for 20 days. This was only one of three glaciers over which the expedition made its way.—Department of the Interior.

ARTICLES IN CURRENT PERIODICALS.

American Journal of Botany, December, Brooklyn Botanic Garden, Lancaster, Pa., $7.00 a year, 75 cents a copy. Studies on the Growth of Root Hairs in solutions III. The effects of Concentrations of $CaCl^2$ and $Ca(OH)^2$ by Clifford H. Farr. Variation in Homoeotypic Division in Ranunculus Acris, by Helen Sorokin. The Measurement of the Rate of Water-vapor Loss from Leaves under Standard Conditions by Bernard S. Meyer.

Journal of Chemical Education, December, Rochester, New York, $2.00 a year, 35 cents a copy. Protection against Corrosion by Means of Metallic Coatings by William Blum, U. S. Bureau of Standards, Washington, D. C. What Chemistry Should Every Adult American Know? by John C. Hessler, Knox College, Galesburg, Ill. A Comparison of Content and Accomplishment in Chemistry of Students in English and American secondary Schools by S. R. Powers, Teachers College, Columbia University, New York City.

Journal of Geography, December, A. J. Nystrom and Company, 2240 Calumet Ave., Chicago, Ill., $2.50 a year, 35 cents a copy. The Sheep and Wool Industry of Australia by E. Pye, Petersham Boys' High School, Sydney, Australia. The Meat Packing Industry by Esther Egan, Chicago, Ill. Testing in Commercial Geography by H. O. Lathrop, State Teachers College, Whitewater, Wis.

National Geographic Magazine, January, Washington, D. C., $3.50 a year, 50 cents a copy. Seeing America with Lindbergh by Lieutenant Donald E. Keyhoe, U. S. M. C. (Retired). Bird Banding, the Telltale of Migratory Flight by E. W. Nelson, formerly Chief, Bureau of Biological Survey, United States Department of Agriculture.

Popular Astronomy, December, Northfield, Minnesota, $4.00 a year, 45 cents a copy. Sarah Frances Whiting, by Annie J. Cannon, Harvard College Observatory. The Astronomical Fraternity of the World by David B. Pickering.

School Review, December, The University of Chicago Press, Chicago, Ill., $2.50 a year, 30 cents a copy. Some Disquieting Aspects of Our Athletic Program by C. W. Whitten, Manager, Illinois High School Athletic Association. Failures in Our High Schools by Helen H. Cowing, Lincoln High School, Cleveland, Ohio. Junior High School Science by Edward E. Cureton, University of Oregon.

Science, Grand Central Terminal, New York City, $6.00 a year, 15 cents a copy. Dec. 9, Hospital and Laboratory by Dr. Rufus Cole, Hospital of the Rockefeller Institute, New York City. Dec. 23, Some Applications of Physical Chemistry to Medicine by Albert P. Mathews, University of Cincinnati.

Scientific American, January, New York, $4.00 a year, 35 cents a copy. Ancient Mayan Astronomy by Herbert J. Spinden, Ph.D., Peabody Museum, Harvard University. How Do the Life Processes Work? by William Seifriz, Ph.D., University of Pennsylvania. Will the Steam Automobile Return?

Scientific Monthly, January, The Science Press, New York, $5.00 a year, 50 cents a copy. Wild Life in Louisiana by Percy Viosca, Jr., State Biologist of Louisiana. America's Influence on the Development of the Sciences by Dr. Joseph Mayer, Tufts College. The Race for Sweetness by Dr. J. J. Willaman, The University of Minnesota.

The Mathematical Gazette, G. Bell and Sons, London. October, 1927, The Approach to the Calculusk, Prof. D. K. Picken; The Choice of Units in the Teaching of Mechanics, a Discussion. December, 1927, Term-by-Term Integration of Infinite Series, Prof. H. S. Carslaw; The Equation of Activity in Dynamics and the Principle of Zero Activity in Statics, Prof. H. R. Hassé; The Laws of Motion, a Dialogue. G. H. Lester.

CURRENT SCIENCE

KEEPS THOUSANDS OF SCIENCE CLASSROOMS ABREAST OF THE TIMES

Just a few of the topics treated in 1927

Agriculture: Manufactured articles of rubber taken from a desert plant of southwest United States—the guayule—entered the market. Edison and his assistants demonstrated the value of milkweeds as sources of rubber. The effect of the exact length of daylight on flowering and fruiting plants was further confirmed.

Biology: Existence of a newly-discovered food essential, vitamine E, was confirmed. Its particular service seems to be in connection with the use of iron by the body. Several new medical uses for dyes were discovered, not only to destroy germs, but to affect tissues and body processes. Dr. Small, of Philadelphia, believes that he found the germ that may cause rheumatism.

Chemistry: The discovery in 1927 that it is possible to electroplate rubber will be outstanding in its benefits to industry. Carbon dioxide snow—"dry ice"—arrived upon the market. From "water gas"—the product of steam upon white hot coke—were made such useful products as methanol (wood alcohol) a useful solvent, gasoline substitutes, and even solid paraffin-like substances that will be further developed this year. New products from cotton and acetic acid, called "celanese," "cellophane," and the like, were presented for use as textiles, wrappings, etc.

Civil Engineering: The two most remarkable achievements completed in 1927 were at opposite ends of our nation. They were the gigantic Carquinez Bridge in California, with two 1,000-foot spans, and the two-mile Holland Tunnel under the Hudson River at New York.

Communication: Television (or telorama) was one of the most spectacular achievements of the year. Pictures of moving objects were sent for many miles, both by wire and by radio. The regular commercial two-way radio telephone service between America and Europe was established, and the first long-distance line to Mexico City completed.

Health: Ultra-violet light and its value to health became a matter of much investigation and interest. New glasses that would permit more of the ultra-violet from the sun's rays were put on the market. The discovery that various foods, particularly fats and oils, but also certain cereals, as oats, could be "irradiated" by exposure to ultra-violet lamps, and that these foods would then prevent rickets, a bone disease, led to a new method of treatment for that trouble.

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CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS, TWENTY-SEVENTH ANNUAL MEETING, FRIDAY, NOV. 25, 1927, CASS TECHNICAL HIGH SCHOOL, DETROIT, MICH.

We attend an educational conference for practical and inspirational benefits which we may receive from it. We wish to exchange ideas with others who are doing similar work, and to hear stimulating addresses by men outstanding in their fields. We judge a conference successful if it offers these opportunities, and especially if the information is presented in an enjoyable manner. Perhaps the officers of the Association would add that to be judged successful, everything must run smoothly. From all these standpoints, the 1927 meeting was a success.

On Friday morning at 9:30 the program opened. Music was furnished by James Young from the College of the City of Detroit. Frank Cody, Superintendent of Schools of Detroit, gave the address of welcome. The Vice President, W. F. Roecker, Boys' Technical High School, Milwaukee, responded for the Association.

The preliminary report of the Resolutions Committee was read by Charles A. Stone, the University of Chicago. This report will appear in full later.

Two very different but interesting and informational addresses constituted the morning's program: the first by Professor Wm. H. Hobbs, Head of the Department of Geology, the University of Michigan, on "Exploring at the North Pole of the Winds," and the second by Professor Chas. H. Judd, Director of the School of Education, the University of Chicago, on "Recent Experiments which Throw Light on the Nature of Mathematical Thinking." These addresses had an appeal for everyone. We were fortunate, indeed, to have had two such eminent men on the program.

The section meetings were held in the afternoon. Many of the papers given here will appear in the official journal SCHOOL SCIENCE AND MATHEMATICS. Attendance at these meetings was approximately as follows: Biology—21; Chemistry—41; Physics—25; Mathematics—60; General Science—55; Geography—12.

At the close of the section meetings, time was given for the inspection of exhibits. We appreciate the cooperation of the firms who furnished these. At four o'clock many took advantage of the excursion to Parke Davis & Co.

At 5:30, at the Hotel Statler, the annual reception was held, and at 7 o'clock the annual dinner. A most excellent address was given by Professor Elliot R. Downing, the School of Education, the University of Chicago. His subject was "The Added Years." We do not describe such a message as this. The inspiration which we receive from it speaks for it. A further pleasure was afforded us in the interesting address of Professor N. Henry Black of Harvard on "The Schools of Germany." This was, indeed, an unusually worthwhile evening.

We greatly appreciate the work of those who were responsible for the success of this conference. They were men and women already busy with their own duties. We are indebted to the speakers who made the meetings so profitable, to R. H. Struble who had charge of local arrangements, to W. F. Roecker, chairman of the Membership Committee, to the officials of Cass Technical High School, to all officers, and especially to the president, Dr. E. R. Breslich, the School of Education, the University of Chicago.

SATURDAY MORNING, NOVEMBER 26.

At eight o'clock the president called the business meeting to order. The annual reports of the president, secretary, and treasurer, and of the Auditing, Necrology, Membership, Nominating, and Resolutions Committees were given. Each report was accepted.

The president expressed the need of retaining our advertisers in the yearbook, and thus the need of making them feel that they are getting results. He reported a total of $801 advertising, and $739.53 expenses, leaving a sum of $61.47.

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The report of the treasurer, Mr. Gingery, showed that the total receipts for the year were $3,240.38, the expenditures $2,488.49, leaving a balance of $751.89.

Mr. Wade, chairman of the Auditing Committee, was absent. His report, which was read, stated that he found the treasurer's books correct in every particular. It added, "The Association has been fortunate to have had such competent and faithful service as Mr. Gingery has rendered.

Mr. Turton, chairman of the Necrology Committee, reported the deaths of three members: Mr. Erwin Homuth, South Division High School, Milwaukee; Miss Ida MacLean, Chicago; and Mr. Allan Peterson, East High School, Des Moines, Iowa.

Mr. Roecker, chairman of the Membership Committee, listed the members by states. The distribution is as follows: Illinois, 47.7 per cent; Indiana, 10.7 per cent; Wisconsin, 10.6 per cent; Michigan, 5.5 per cent; Ohio, 5.5 per cent; Iowa, 4.9 per cent; Minnesota, 1.7 per cent; Missouri, 3.2 per cent. Eleven other states each furnish one per cent of the total enrollment. Mr. Roecker recommended that the next chairman appoint a committee with one representative from each state. He suggested that we try to arrange with the editors of the journal for a page where we can express ourselves from time to time.

In the absence of Mr. H. R. Smith, Mr. Warner acted as chairman of the Nominating Committee. The following nominations were reported: President, W. F. Roecker, Boys' Technical High School, Milwaukee, Wis.; Vice President, L. E. Hildebrand, New Trier High School, Winnetka, Ill.; Secretary—elected last year for a period of two years; Corresponding Secretary, Amy L. Coats, Northwestern High School, Detroit, Mich.; Treasurer, Ersie S. Martin, Arsenal Technical High School, Indianapolis, Ind., and Assistant Treasurer, Russell S. Howard, Lyons Township High School, La Grange, Ill. The secretary was instructed to cast a unanimous ballot for all nominees.

The report of the Resolutions Committee was read by the chairman, Mr. Charles A. Stone. This report, and the report of the president, secretary, treasurer, and Necrology Committee will be printed in full in SCHOOL SCIENCE AND MATHEMATICS.

Dr. S. R. Powers gave a tentative report of the committee on National Council of Science Teachers. The committee consists of: Frank E. Goodell (chairman), Dr. E. R. Downing, Jerome Isenbarger, Ira Davis, Francis D. Curtis, Alfred Davis, C. B. Marquard, S. R. Powers, Haner A. Webb, Ada Weckel, and Viva Dutton Martin.

By means of questionnaires, they found that many science teachers favor the organization of the council. Recommendations were submitted. The report was referred to the Executive Committee.

The business meeting was then adjourned.

At 9:30 the general program opened. The first address was given by Professor W. D. MacMillan, the University of Chicago. His subject was "The Evolution and Dissolution of Matter." The second address was by Professor Henry C. Cowles, the University of Chicago, on "Botany in Its Human Relations." This Saturday morning program had an appeal for everyone, and was unusually profitable and interesting.

WINNIFRED J. SHEPARD,
Secretary.

BIOLOGY SECTION.

The Biology Section of the Central Association of Science and Mathematics Teachers met Friday, November 25, 1927, 1:30 p. m. in Room 209, at the Cass Technical High School, Detroit.

The chairman, J. R. Locke of Highland Park High School, Detroit, called the meeting to order. He extended to the twenty-five biologists present a very hearty welcome. The nominating committee was appointed by the chairman.

The first speaker on the program was Dr. L. T. Clark, Junior Director of the Research Department of Parke, Davis and Company, Detroit. His paper was on "The Manufacturer of Biological Products." Two reels

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of motion pictures followed the reading of the paper. These reels took us through the Parke, Davis and Company Laboratories and we were shown how several of the biological products were produced. The making of diphtheria, scarlet fever and erysipelas antitoxins were some of the products shown. These represented a few of the comparatively small number of the entire biological products subjected to a definite potency at the present time. These serums are tested for potency by comparison with standard tests under control of the U. S. Hygienic Laboratory.

The next speaker was Dr. Carl LaRue, Professor of Botany at the University of Michigan. The topic of his talk was "The Para Rubber Tree in the Amazon Valley." The talk was illustrated by motion pictures taken along the Amazon River while Dr. LaRue was in charge of a government expedition for the United States. This was an expedition by the government for an investigation of the value of rubber plantations in the Amazon River Region.

The last speaker was Dr. H. H. Bartlett, Director of Botanical Gardens and Arboretum, University of Michigan, who gave a very inspiring and illuminating talk on "The Teaching of Osmosis by Biology Teachers."

A brief discussion by members of the section followed the last speaker.

The nominating committee reported the following names for officers for next year: Chairman, Mr. T. O. Cantwell, Lake View High School, Chicago; Vice-chairman, Miss Rose Maddock, Englewood High School, Chicago; Secretary, Miss Aline Cullison, Crane Junior College, Chicago. The report was accepted and these officers elected. The meeting adjourned.

ALINE CULLISON,
Secretary.

CHEMISTRY SECTION.

The section meeting of the Chemistry Section was held in Room 217 of the Cass Technical High School, Detroit. The chairman of the meeting was Mr. Raymond W. Osborne, Assistant Principal of the Francis W. Parker School of Chicago. The attendance was sixty. In the absence of the secretary, the vice-chairman was requested to serve as clerk of the session.

The first paper by Dr. F. O. Taylor of the research laboratory of Parke Davis and Co. was very scholarly and intensely interesting. He brought to our attention the fact that some of our most valuable drugs are obtained from the flowers of our gardens or more commonly from the plants which grow here, there and everywhere around us in our barnyards. At four o'clock the section was invited by Dr. Taylor to go on an inspection trip to the Parke Davis plant and laboratories which unfortunately most of us missed on account of the length of our programs.

Following Dr. Taylor's address, there were five interesting papers which dealt with some phase of chemical instruction in high school or college in the following order: "Some Aims in Elementary Chemistry," Dr. R. C. McAlpine of the University of Michigan; "Helps in Teaching Industrial Chemistry," Dr. Alex. C. Burr, the College of the City of Detroit. "A Summary of a Five Year Study of Certain Aspects of Learning in High-School Chemistry," Earl R. Glenn, Lincoln School of Teacher's College, New York City; "What Constitutes Efficient Demonstration Work in Teaching Elementary Chemistry," Raymond R. Jared, Cass Technical High School, Detroit; "The Cooperative Method of Handling the Overload," Dr. Andrew F. McLeod, Crane Junior College, Chicago.

Chairman Osborne should be congratulated for the fine quality of the program which attracted a large and appreciative audience on account of the length of the program; no time was left at the close of the meeting for general discussion. The following officers were selected for next year: Chairman, Andrew F. McLeod, Crane Junior College, Chicago; vice-chairman, Raymond R. Jared, Cass Technical High School, Detroit, secretary, Frances Church, East High School, Des Moines.

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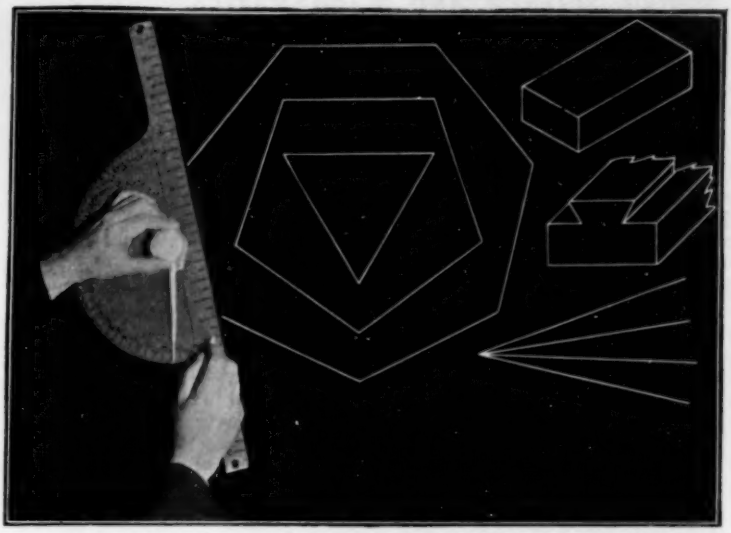

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GENERAL SCIENCE SECTION.

The meeting was called promptly at 1:30 p. m., Nov. 25, by the chairman, Francis D. Curtis, Ph. D., of the School of Education, University of Michigan. After a few remarks, Dr. Curtis appointed the Nominating Committee, which was as follows: G. G. Woods, D. C. Tate, Martha Quick. This committee met at once.

The chairman then introduced the first speaker, Mr. C. L. Thiele, Assistant Director of Exact Sciences of the Detroit Public Schools. Mr. Thiele's subject was "An Investigation of New Curricular Units in General Science."

Mr. Thiele has done considerable research in the various text books to find the various subjects treated and if the biological and the physical sciences are given the same consideration. He then gave an outline of the work being done in science in the Junior High Schools of Detroit.

Mr. J. O. Frank of the State Normal School, Oshkosh, Wis., was the next speaker. Mr. Frank did not like the subject as stated in the program "Superstition and the Teaching of General Science," so changed it to "Content of General Science Courses." He finds the content varies a great deal. He is of the opinion a committee should be appointed to outline a standard course.

Due to the fact Mr. Beauchamp had to meet another appointment, the order of the speakers was changed and Mr. Beauchamp appeared next on the program. His subject was "Supervised Study in Science." Mr. Beauchamp states there have been two view-points in the teaching of science. First, the old study, recite and drill type which was the method of procedure in most any of the courses offered. The second viewpoint which Mr. Beauchamp discussed was, first to stimulate thought or create questions and then make the student conscious of a method of procedure. With this interest created, greater work can be accomplished.

Following Mr. Beauchamp, the report of the nominating committee was given, which was as follows: J. O. Frank, chairman; Harvey F. Johnson, vice-chairman and C. L. Thiele, secretary. A motion was made that the report be accepted and the secretary be authorized to cast one ballot unanimously electing the officers. The motion was carried and the secretary cast the vote duly electing the officers.

The next speaker was S. R. Powers of Teachers' College, Columbia University, whose topic was "Goals for Accomplishment in General Science." In his discussion, he gave a report of a questionnaire sent out to parents of pupils in the Horace Mann School of New York. The parents were asked to check a list of objectives as they considered them in the order of their importance. The objective relating to science and health came first. The one relating to phenomena of plants stood high, while the objective relating to naming the planets came last. As a result of Mr. Power's discussion one could not but question himself as to whether he is placing emphasis where it should be.

Ira S. Davis of the University of Wisconsin was the next to present his paper, the subject being "The Contract Method of Teaching Science." In this paper Mr. Davis outlined the method of conducting the work at the University High School. Contracts are prepared which cover certain pieces of work. At first these are to cover a short time, possibly three or four days, and as the student progresses the contracts become longer. This type of procedure permits each pupil to progress as rapidly as he is able to. It has replaced the old type of recitation and the period has become a work period. It has increased the number of good pupils and made the good pupils better. It also shows up the poor pupils.

Following Mr. Davis, there was a period for discussion and from the questions asked and the number of people entering into the discussion one could not but believe the meeting was a success. At the close of the discussion the meeting was adjourned.

HARVEY F. JOHNSON,
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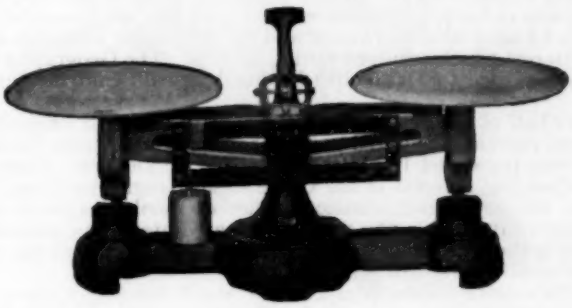

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GEOGRAPHY SECTION.

A select group of teachers interested in Geography met on Friday afternoon, November 25, at the Cass Technical High School, Detroit, Michigan. It was the rare good fortune of the Geography Section to be addressed by Dr. Hobbs, head of the department of Geology at the University of Michigan. He lectured rather informally on "Cruises Along By-ways of the Pacific," telling of a research trip which he had taken under unique conditions on American and Japanese battle ships and smaller crafts, even in native canoes, among islands of the Pacific from Japan southward. The object of the trip was to study the nature of mountain making in this area and the relation of mountain chains to oceanic deeps. He explained the scientific conclusions drawn from his findings during this trip with the direct simplicity which everyone could understand, as only a man with Dr. Hobbs' masterful grasp of the subject could do. The charm of his presentation was enhanced by the beautiful colored slides which he used as illustrations and by the casual inclusion of items of human interest which occurred during his trip. The Geography Section feels deeply indebted to Dr. Hobbs for his delightful contribution to the program.

The latter half of the program was devoted to practical suggestions for classroom use especially adapted to the teacher of Commercial Geography. The topic was presented by Miss Ona Giffin of Decatur, Illinois, who spoke on "Creating Interest in the Commercial Geography Class." Miss Giffin is an energetic, enthusiastic teacher of much experience in Commercial Geography work. She presented many interesting, practical suggestions which she had worked out carefully and subjected to the eliminations and alterations resulting from actual class room use.

Miss Giffin's more formal presentation was followed by three shorter papers each setting forth in some detail one particular device found of practical value in teaching Commercial Geography. These devices were both clever and original. The papers were as follows: "An Opportunity for Student Activity in Commercial Geography as Presented in Northern High" (Detroit, Michigan), by C. W. Blanchard, Northern High School, Detroit, Michigan; "A Project in Commercial Geography" by J. R. Schindler, Central High School, Detroit, Michigan; and "The Value of the Bulletin Board in Teaching Commercial Geography," by Miss Grace A. Robinson, Cass Technical High School, Detroit, Michigan.

A short business session concluded the meeting. The following officers were chosen for the ensuing year: Chairman, J. C. Baird, Harrison Technical High School, Chicago; Vice-Chairman, Helen Southgate, Michigan City High School, Michigan City, Indiana; Secretary, Mabel Washburn, Shortridge High School, Indianapolis.

VIVA DUTTON MARTIN,
Chairman of the Geography Section.

MATHEMATICS SECTION.

The meeting was called to order by the chairman, Joseph A. Nyberg, Hyde Park High School, Chicago. In the absence of the secretary, Margaret Dady, Waukegan Township High School, Waukegan, Ill., the chairman appointed Edwin W. Schreiber of Ann Arbor as secretary pro tempore, who read the minutes of the 1926 meeting held at Crane Junior College, Chicago. Mr. Nyberg then introduced Miss Hildegarde Beck, Northwestern High School, Detroit, who presented a paper entitled, "Adjusting the Course of Study in Ninth Grade Mathematics to the Ability of the Pupil." Mr. Charles A. Stone, University High School, Chicago, followed with a paper on "Functional Analysis of a Unit of Work in Ninth Grade Mathematics." The third paper was presented by Mr. Fred A. Burroughs, John Adams High School, Cleveland, Ohio, entitled: "An Investigation of Achievements in Plane Geometry."

The chairman appointed a Nominating Committee of three: Prof. Theo. Lindquist, Ypsilanti; Prof. John R. Clark, New York University; and Mr. J. V. McNally, Detroit. The committee submitted the follow-

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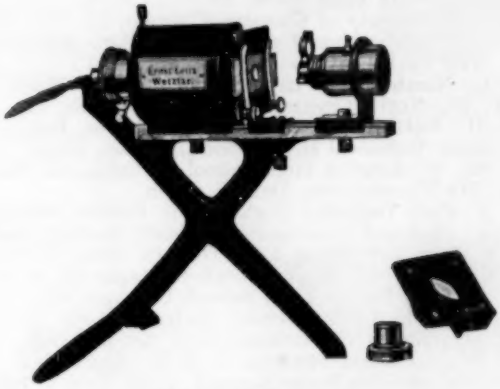

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ing report which was unanimously accepted: Edwin W. Schreiber, chairman, Graduate Student, University of Michigan; Martha Hildebrandt, vice-chairman, Proviso Township High School, Maywood, Ill., Margaret Dady, secretary, Waukegan Township High School, Waukegan, Ill.

More than sixty persons were in attendance at the Mathematics section. Twenty-three members of the Central Association were present and thirty-five visitors registered. The list follows:

MEMBERS

Anning, N., University of Michigan, Ann Arbor, Mich.
Branigin, C. D., 19248 Grandview, Detroit, Mich.
Breslich, E. R., University of Chicago, Chicago, Ill.
Carnahan, W. H., Shortridge High School, Indianapolis, Ind.
Clark, J. R., New York University, New York, N. Y.
Coats, Amy L., Northwestern High School, Detroit, Mich.
Coultrap, M. W., North Central College, Naperville, Ill.
Crandall, G. H., Culver Military Academy, Culver, Ind.
Doub, A. V., Cass Technical High School, Detroit, Mich.
Gingery, W. G., Washington High School, Indianapolis, Ind.
Keal, H. M., 241 Tuxedo Ave., Detroit, Mich.
Leonard, C. L., Cass Technical High School, Detroit, Mich.
McNally, J. V., Sherrard Intermediate School, Detroit, Mich.
Merici, Sister Mary, 5206 Field Ave., Detroit, Mich.
Nyberg, J. A., Hyde Park High School, Chicago, Ill.
Petty, D. T., Francis Parker High School, Chicago, Ill.
Sawyer, P. N., Redford High School, Detroit, Mich.
Schorling, R., University of Michigan, Ann Arbor, Mich.
Schreiber, E. W., Graduate Student, U. of M., Ann Arbor, Mich.
Stirwalt, Cyrena, Indiana State Normal, Terre Haute, Ind.
Stone, C. A., University High School, Chicago, Ill.
Walker, N. C., Cass Technical High School, Detroit, Mich.
Wines, L. D., Ann Arbor High School, Ann Arbor, Mich.

VISITORS

Appleman, Ira. R., 69 Seward Ave., Detroit, Mich.
Beck, Hildegarde, Northwestern High School, Detroit, Mich.
Betts, Amy, Dearborn High School, Dearborn, Mich.
Bower, E. O., East Technical High School, Cleveland, Ohio.
Burnham, D., Lansing High School, Lansing, Mich.
Burroughs, F. A., John Adams, High School, Cleveland, Ohio.
Chipman, Hope H., University High School, Ann Arbor, Mich.
Cook, L. A., Mansfield Senior High School, Mansfield, Ohio.
Craig, N. E., 2697 Tuxedo Ave., Detroit, Mich.
Crawford, Mildred, Roosevelt High School, Ypsilanti, Mich.
Crow, Agnes, Michigan State Normal College, Ypsilanti, Mich.
Dionysia, Sister Mary, 5206 Field Ave., Detroit, Mich.
Edwards, W. H., 13441 Chelsea Ave., Detroit, Mich.
Felice, Sister Mary, St. Mary's College, Prairie du Chien, Wis.
Giffin, Ada B., 5643 14th St., Detroit, Mich.
Gillard, M. J., 11737 Nardin Ave., Detroit, Mich.
Grace, Lida J., Cleveland Inter. High School, Detroit, Mich.
Hill, Katharine, University High School, Ann Arbor, Mich.
Kennedy, Kathryn, Normal Training High School, Terre Haute, Ind
Lindell, Selma A., University High School, Ann Arbor, Mich.
Lindquist, T., Michigan State Normal College, Ypsilanti, Mich.
Loss, Nellie, 219 E. Third St., Flint, Mich.
Malone, Bertha E., Northern High School, Detroit, Mich.
Moss, F. H., Senior High School, Kokomo, Ind.
Murray, Alice L., Student Teachers College, Ypsilanti, Mich.
Pettengill, T. E., University of Detroit, Detroit, Mich.
Pinder, W. H., 1131 Emery Ave., Detroit, Mich.
Pirie, D. H., 236 Harman Ave., Detroit, Mich.
Poch, R. O., Condon Inter. High School, Detroit, Mich.

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Shellenbarger, R. C., Junior College, Bay City, Mich.
Walsh, May F., Northern High School, Detroit, Mich.
Watkins, E. E., Northern High School, Detroit, Mich.
Worden, Orpha E., Teacher's College, Detroit, Mich.
Wyman, C. E., 15374 Griggs Ave., Detroit, Mich.

EDWIN W. SCHREIBER,
Secretary.

PHYSICS SECTION.

Held in Room 417—Cass Technical High School, Detroit, Mich., Nov. 25, 1927.

The meeting was called to order by the chairman, Mr. M. J. W. Phillips who appointed the following Nominating Committee: G. B. Eisenhard, Culver Military Academy, Culver, Ind.; R. J. Coats, Detroit Central High School; J. M. Carl, Collinswood High School, Cleveland, Ohio.

There being no further business, the meeting was turned over to the program. A paper was given by Mr. Oscar Himebaugh of Central High School, Akron, Ohio, on the "Common Units of Measure used in High School Science Text Books." This was a report of a very comprehensive investigation involving an analysis of some twenty-four high school science text books and five elementary school arithmetic books. The study revealed that more time should be given to the study of the vocabulary of our common units of measure.

In the absence of Mr. E. W. Kiebler of East Lansing High School, East Lansing, Mich., his paper entitled, "A List of Experiments in High School Physics," was used by Mr. Floyd I. Leib of Ypsilanti, Mich. This was a report of a study designed to define a list of high school physics experiments by taking those common to five manuals and securing a rating by submitting them to a group of teachers of physics. Some forty-seven returns were tabulated and only those experiments accepted which were agreed upon by twenty-five or more. This constituted only a temporary report as the investigation is being extended and will be reported in detail in this journal upon its completion.

A paper reviewing a five year period of experimentation with objective tests in physics was used by Mr. Ellsworth S. Obourn, of the John Burroughs School, St. Louis, Mo.

The section was most fortunate in having present, Mr. N. Henry Black of Harvard University who spoke briefly on his impressions of science teaching abroad.

As this concluded the program, a report of the Nominating Committee was called for and was given as follows:

Chairman—Mr. J. M. Kurtz, Bowen High School, Chicago, Ill.

Vice Chairman—Mr. Ellsworth S. Obourn, John Burroughs School, St. Louis, Mo.

Secretary—Mr. H. Clyde Krennerick, North Division High School, Milwaukee, Wis.

Upon a motion from the floor duly seconded that this report be accepted and there being no discussion, the motion was passed.

There being no further business the motion to adjourn was made, seconded and passed.

ELLSWORTH S. OBOURN,
Secretary.

ANNUAL REPORT OF THE PRESIDENT.

At the end of the year the president wishes to express his appreciation and thanks to all who have helped him carry on the work of the association.

The task of writing and publishing the yearbook falls largely to the president. This publication is made possible through the financial support derived from advertisements. Because the program appeals only to a very limited group of advertisers, such as publishers and dealers in equipment, it is necessary to make these dealers feel that they are getting results. The cost of printing and publishing increases each year, and every

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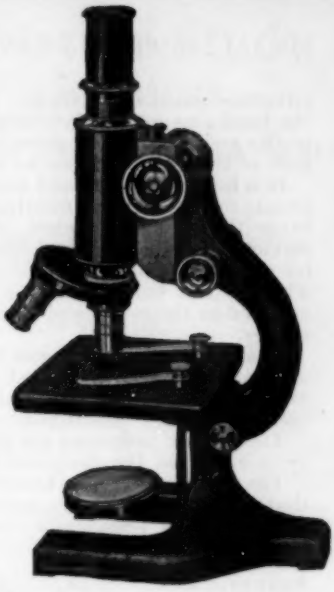

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advertiser must be retained. The response this year has been very good, the total amount of advertising secured being $801.00. If every member of the association who gives an order would mention the year-book this task of the president can be made very light.

It is becoming more and more difficult to secure distinguished platform people for our general meetings. Several requests were turned down because the men approached felt that they should obtain more for their services than the president felt we were able to offer. The amounts asked for ranged to $150 a lecture. However, we succeeded in getting speakers who are not only nationally known, but whose lectures are especially adapted to the needs and interests of teachers of the sciences and mathematics.

Much credit is due to our local chairman, Mr. R. H. Struble, and his assistants, who have carried a large burden in making all the arrangements that necessarily have to be looked after by someone who is in contact with local conditions.

The section programs are all attractive. Every chairman had his program ready at the designated time.

The following is the financial statement of the president. It shows that the income from the yearbook paid all costs of printing and mailing and all of the president's expenses, leaving a balance of $61.47 to the association.

ADVERTISING OBTAINED:	5 2-page ads	$160.00	
	35 1-page ads	560.00	
	9 ½-page ads	81.00	
	Total	$801.00	$801.00
EXPENSES:	Materials	$ 2.60	
	Stamps, postage, etc.	11.80	
	Telephone calls	.60	
	Student help	4.50	
	Clerical help	31.50	
	Total	$ 51.00	
	Printing, addressing, mailing	$575.23	
	Postage, express	58.20	
		$633.43	
President's commission:	5% on $500	$ 25.00	
	10% on $301	30.10	
		$ 55.10	
	Total Expenses		$739.53
	Balance		$ 61.47
Amount collected for ads			$504.00
Amounts standing out			$297.00

Respectfully submitted, E. R. BRESLICH.

REPORT OF THE NECROLOGY COMMITTEE.

The necrology committee offers the following report:

Three members have died the past year: Mr. Erwin Homuth of the South Division High School, Milwaukee; Miss Ida MacLean, Chicago; and Mr. Allan Peterson, East High School, Des Moines.

Mr. Peterson was one of the best known physics teachers in Iowa. He was a member of our association since 1914. Miss MacLean had been a member for four years. Mr. Homuth was one of the younger members, joining the association in 1924.

Respectfully submitted, CHAS. M. TURTON.

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Memberships	1,616.00
Exchange	.55
Advertising in year book	865.00
Replaced check	2.50
Sale of Dinner Tickets	123.75
Non-member Admissions	20.50
Total Receipts	$3,240.38
DISBURSEMENTS:	
To Mr. Turton, Subs	$1,132.00
For printing	701.99
General	654.50
Total Disbursements	$2,488.49
BALANCE ON HAND	$751.89

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REPORT OF THE COMMITTEE ON RESOLUTIONS.

Resolved, that the Central Association of Science and Mathematics Teachers extend a vote of thanks to Assistant Superintendent Miller, the teachers, students and attendants of the Cass Technical High School for their efforts in looking after the comfort and convenience of the visitors, to the students of the Northwestern High School for the splendid music, and to Mr. Strubel, local chairman, whose untiring efforts contributed much to the success of the meeting.

C. A. STONE.

CATHODE RAYS MAKE BURNS.

Injuries caused by cathode rays streams of electrons projected from Dr. W. D. Coolidge's recently invented tube, closely resemble burns due to overdoses of X-rays and are similarly stubborn about healing. This is indicated by experiments performed by Dr. Victor C. Jacobson and Dr. Kenneth C. Waddell of the Albany Medical College, to be announced soon in the scientific journal, *Archives of Pathology*.

Rats were used as subjects of the experiments. The animals were wrapped in jackets of copper foil to protect them from being rayed all over, and only a spot about an inch in diameter on the upper abdomen was left exposed.

The first sign of effect by the cathode rays was in the change of hair color, from white to yellow. Then the skin appeared to be tender, and finally developed pronounced sores, which were very slow to heal. When the rats were chloroformed and the skin subjected to microscopic examination, the details of the damage resembled closely those of X-ray burns. The experimenters state that it now appears highly likely that X-ray burns are really due to cathode rays generated by the impact of X-rays on solid or liquid objects which they encounter.—*Science News-Letter*.

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